Vol. 65 No. 8 February 21, 1984

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Seismology

Vol. 65, No. 8, Pages 65 - 72

February 21, 1984

Seismology

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L. Serpe [Oupertnent of Geological Setances, Cornell University, libres, NY [4551], T. Setzer, K. Farmer, L. Sroue, J. Oliver, E. Saulman, J. Sharp, and O. W. Steeoles onteractry, these, NY 14351), T. Setzer, K. Farmer, t. trous, J. Oliver, E. taulman, J. Sharp, and O. W. Steeples

COOMP pro(() ing across the midtontinent gaophysical anomaly in northeastern Kasear ravaels structural basims and other (setures of the Fracambrica Ravannavan rite burled beneath the Phanetrolic cover. The AD-hm-wide main hasin is neymmetrie, with a maximum depth of the on the mest and 8 hm os the west. The health [1() is characterized by a lower layered sequence of strong continuous went dipping reliactors which may be correlated with Hiddle Kawaenavao interhedded volcanie and elestic rocks amposed along the MGA (o the Lafe Superior region. Overlying this layered esquence is a same of wesk, discontinuous reliserors correlated here with the predominantly elestit rocks characteristic of the Upper Kawaenaves sequence near Lake Superior. A ascond cilited but challower hasin line to the east of the min hasin and appears to be ilited predominantly with clustic esdimentery rocks. The character of the asint hasin and appears to be ilited predominantly with clustic esdimentery rocks. The character of the main hasin and appears to be ilited predominantly with clustic esdimentery rocks. The character of the main hasin and appears to be litted predominantly with clustic esdimentery rocks. The character of the beneath the riit fib basis. Mornat l'autic shaceleted with the riit dip at conderce angles to the asstructure and the control of the control of the control of the rock of the prediction of predicting structures appears to have cocurred in many other pitte prelitied by COCORP, the seldence is (noomelistee on this point is the case of the Kamees and sizewbors suggest their newmentric esquences of layered relieters are chereteristic in esquences of layered

Tectonophysics

8110 Convect(on currento THE INTERACTION OF A SUBBUCTING LITHOSPHER SLAB WITH A CHEMICAL OR PRASE BOUNDARY U.R.Chelatoneen [Mak-Planck-Inetitut, Sear-etrasso 23, 6500 Meine, PR Germany], D.A.Yuor

elsewhore suggest ther naymastric sequences of kanese and reliectors are sharecteristic, and perhaps disposed of rife both about the name of the comments of the continual geophysical enough. [COCORP, Kausanswan ric. tasics, Paper W 191]

U. A. Chelatoneen [Max-Plonck-Inetitut, Sear-etraso 2], 5500 Meine, PR Gormeny! D. A. Yuon Me have used a finite element convection pouch to determine the conditions for ponetro-tion of the subdected plots into the lower mantic. A temperature dependent non-Newtonian rhoology is used to schleve plete-like behavior of the upper and einking thermal boundary loyer. The S50 km discontinuity is taken as either chemical or phese boundary or a combinction of both. It is represented by a newter chein which elfoots editional buoyancy when distorted. When the compositional deflected eldewards at the boundary and two-isyar convection perveits. A resulting daspreasion of the houndary by about loo km should be detectable with estantic methods. Solow 55 the alse plungoe eaveral hundred killersters jote the lower mantle end below 2t it will probably not even before the core mantle boundary and entensive mixing le espected with a pure phase charge a negative castabileh a type of 'jesty' double layer convection. A more moderate alope oan eld o small chemical deceity contrast to prevent ties shout the physical nature of the 50 km² appears possible od uypaning attive of the 650 km² appears possible od uypaning attive of the 650 km² appears possible od uypaning attive of the 650 km² appears possible od uypaning attive of the 650 km² appears possible of uypaning attive of the 650 km² appears possible of uypaning attive of the 650 km² appears possible of uypaning attive of the 650 km² appears possible of uypaning attive of the 650 km² appears possible of uypaning attive of the 650 km² appears possible of uypaning attive of the 650 km² appears possible of uypaning attive of the 650 km² appears possible.

8199 Tectonophysics
ORIGIN OF LUTGY: THE BEAGLE TO SKABEAN

H. W. Monard Cinntflute of Marina Resources and Scripps
Institution of Reconography, Le Jolfa, CA 92031)
Thormal subsidence would have droused auctant volcasic
infamin (DAVI). Ancient volcances, if active at preset
rates in the main occan famins, would have produced
1.3-1 those the observed ombar of DAVI. Shallow-said
indicators have been collected from 11% of systes and
another IX appear so be droumed barrier resicer and is
on the IX appear so be droumed barrier resicer and is
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on the IX appear so be droumed barrier resicer and is
on constructional origin of generate volcanic
islands. The PAVI have the name 1-4 km relief as the
islands would have if francated. Monatheless hypothesis
of a constructional origin of gaveno continue to be proposed. Balasive to those hypothesis er the following
(10) sif (our large, acrelve submartur volcanose that bin
been surveyed lach first tops and (21 many small, deep,
inactive, relactively flat-tepped volcances are constructional forms but none with sore than 2 km of relief are
house to be. Thus it is probable that all guyds with
more than 2 km of relief are GAVI but the possible arintended in a volcance that guyds large cough to be of
interest in orunging the spetrogenic bistory of sidplate swells are set DAVI.

J. Geophys. See., B. Paper 480152

Volcanology

8599 Vulcanology (Volcanic Stratigrophy) STRATORAPHIC RELATIONS AND SOURCE AREAS OF ASH-YLDV ETS OF THE BLACK MOUNTAIN AND STONEWALL POUNTA WULCANIC CENTERS, NEVADA

Of Minee, University of

Nevada - Reso, Esso, Navada 89557), T. A. Yogal, S. t.

Notas, J. W. Ervin, E. H. Hekes and L. W. Yourker

Notas, J. W. Ervin, E. H. Hekes and L. W. Yourker

We has, J. M. Ervin, E. H. Perse and L. R. Younfar Rocent work has resulted in major chemges in shared recent work has resulted in major chemges in shared throught of ash-flow element of the late Hiscome Stack Hountain Stack and Sucrease ossignment of ash-flow element in votcome centers, seekers flowwards. Ash-flow tuite opposed around Stonesall Hountain have diliferent trets-clonent patterns and thermolesses of the Thiraty Canyon Tuff, supped from the Black Hountain center, with which they were previously correlated. Hantum concentrations are out titularly useful in detelogation the segatopicality and persogneticity similar tuifs of the two centers titularly useful in detelogation the segatopicality and persogneticity similar tuifs of the two centers that she flow sheet overlying the Spearhead Hember in the Stonewall Hountain aret, herein asped the Civer Cat Canyon Hember, can be traced out therefore the soull for most of the continuously from outliew (seles south of Stonewall Hountain to mear-vent facies on the southern Hant of Stonewall Mountain. This, is conjunction with distribution, theckness, and foctae relations show that these units are the outliers shouts of the Stonewall Hountain well-can't counter; they are berein sanigned to an aviormation, the Stonewall Flat Tuff of lers Hocens Schrouter on the basis of treeq-dement, paleonaghating activation on the basis of treeq-dement, paleonaghating the period of the Spearhand Hamber in the Black Hountain sense are reassigned to the Spearhand Hamber in the Black Hountain while the High Conyon Tuff. The Stonewall Hountain while the High Conyon Tuff. The Stonewall Hountain while the High Conyon Tuff. The Stonewall Hountain while the Black Hountain ernor we analyze probebly wis apprehently settle than previously infaired. Benefit of the Stonewall Previously surface are separated and previously provided the contribution of the Stonewall Previously as apprehently and genetic antify oneshes as a carefulation. tocent work has resulted in major chenges in the beongstiide of the Steneshall Plat Toff as a septrate attriture in the sene of the second sec

E. C. Bullard's First **Heat-Probe** 

Elizabeth N. Shor 2655 Ellemown Road, La Julia, GA 92037

Sir Edward Bullard in 1973 said to me, "Betty, I want in tell you how my lirst ocean heat-flow instrument was made in the summer of 1949." He was theo on his annual 3month visit to Scripps Institution of Oceanography and knew that I was writing a history of the institution. Teddy tas he preferred to be called) was proud of his participation in measuring the flow of heat at sea. The instrument that he described that day never made a heat-flow measurement, but it did establish the reclinique that has been used for more than 30 years.

The following account is a slightly shortened version of our taped emversation on August 5, 1973 (the original audio cassette is in the archives of Scripps Institution of Oceanography, item 81-84). Unfortunately, the reader luses the charm of Teddy's voice and accent, but here for history are his

Bullard: I first became interested in heat

Huw in the early 1930's, I'll send you a conv of a paper that describes some of the background of the early work on land [Bulland, 1939]. It was the British Association, which is like your triple-A S-had a committee on the subject, with Harold Jellreys on it. In the period inst before the war I was developing methods of making heat-flow measurements on land, which had been done extraordinarily badly belore, and hardly suything had been done since about 1880. There was a previous British Association comminee way lack in the 1880's, and I have written a historical paper on this. The historical paper is in Willie Lee's book on hear flow [Bullard, 1966]. He'd asked me to write a summarizing chapter for the book, and I said I worddin't do that, because it's too dull a thing to do, and then he wrote to me and said be thought this was most ourreasonable and improper of me, and he saw no reason why I shouldn't write a summarizing chapter. And so I wrote an histoxical chapter which was really a son of joke chapter and was mostly about the study of hear flow in the 17th century. But it does give the more recem stull.

Well, then, shortly before the war I began to think about measuring heat flow at sea. And the war in '39-the war overrook the plan, and we didn't do anything about it. Shor: Had you developed an incrument at that time?

Bullard: No, I had tleveloped the ideas for the instroment but we had done no hardware development, but I knew what I wanted to do. And we had two schemes for doing it: one was the one we eventually adopted of putting a spike in, and the other was the idea of purting a kind of mattress on the scaffoor and leaving it there and measuring the temperature gradient through it. Theo, after the war I couldn't do this because I couldn't get a ship. Discovery was being used for replenishing lighthouses, and there was no British oceanngraphic ship available innoediately after the war. Then I tried to get Mactrice Ewing to cooperate. He said he couldn't spare any ship time for this purpose. He'd just gone to Lamont. I'd known him-I'd been to sea with him before the war when he was at

Lehigh, in connection with seismic work. Well, theo I went to Canada. I took a job in Canada, going up there in March 1948. And in the summer of 48 1 paid a brief visit to Calilornia. It was tny first visit to La Jolla. Louis Slichter used to run a conference on geophysics every year [at the University of California, Los Angeles]. I went to that, and Louis brought me down here afterwards, and I came down here and met Roger Revelle and Walter Mnnk. My memory is that I went to a party at Roger's, and I met a lot of blundes. I remember La Jolla as being blandes.

I got un very well with Waher and Roger. They asked me to come back the next summer. I forget exactly when, but I got a letter inviting me to work for the summer duwn here, and I said there were several things I'd like to do and one of them was the heat-flow measurement. And I came down here, probably June, July 1949. And I got here and it was suggested that I take on Art Maxwell, who was a graduate student.

Elizabeth N. Shor was raised in Lead. South Daola, alleuded Pasadenia City College (1 year) and Wellesley Gollege (2 years). She has learned a bit about geophysics from George G. Shor, fr., whom she married in 1950. She has writnea (n 1950). She has writ-len two books on the history f paleautology, one on the story of Scripps Institution of Oceanography (where George works and she has worked), and a number of biographical accounts of scientists, especially for the Dictionary of Scientific Biogra-

Well, anyway, I decided to do two things: to investigate the westward drift of the earth's oraguetic field, which was a data analysis problem, and to try and build an apparatus measuring heat flow. Well, then I went to Roger and said we'd like some workshop time. And Roger said he was surry, the workshop was completely taken up with urgent work, and it was impossible to give any work-shop assistance. So I decided that we'd build the thing ourselver. So I went around to the fellows and I hadn't got any workshop assistance—couldn't we work in the workshop, Art Maxwell and myself? This was obviously a slightly embarrassing matter. But we went down to the uld workship in the old shed. I got an office-I shared an office with Waker Mank, over the old director's office in the

original building of Scrippe. Well, we certifd down. This was a substantial job. We designed what-it was the litst time I think that anyone at Scripps had had a watertight equipment for use in the deep sea. I remember the expert advice from Unim D.( Isaacs, and secon, was very much against this. They wanted us to build an emioment that was full of oil - the recorder, the electronics and everything immersed in oil. And I decided against this, I decided to build a waterright apparatus made watertight with Utrings That was, I think, brand new. And we had some interesting experiences with it.

First of all, we had great dilliculty in getring sufficiently strong tubing—alloy sirel tubing secured not to be available in sort of 1inch thicknesses G inches diameter. We evencually found that the people who made ball racet—half bearings—made them by slicing them off syel tubes, and one of the manufatiners of half heatings and half races supplied as with a piece of tubing. And we got some end plates out of good alloy. The stuff was along teinches internal diameter and about three quarters of an incli thick, something like that. And we made up things out of this, with Orings Of course, the Oring had been introduced originally for aircraft-livelenthe systems during the war and was then introdirections the aranium diffusion plant as a matter of making it pressure right. And I'd known of it from these sources. And we de-cided to use this, And it proved extremely effective. We went our and tested these containers, and we never had a leak. Eve never had a leak from an O-ring container at sea. They're used in everything now of course They're used in cameras and seismic equip-

ment and all kinds of things. And we made a very climsy apparatus for this purpose. We decided to do something which I thought I understood rather than something I didn't. So we bought—at least I got from the Bruish Admiralty-galvanous eters, which were very robost and which could be used horizontally. And we lixed these and used plintographic recording and thermocuuples. So it was thotoughly old-fashioned equipment: oo electronics; photographic recording, galvanoueters, reversing switches for eliminating thermal emf's in the switches for entimating interest the equipment. And this equipment I afterwards used oryself, so it is the equipment I describe in my first paper [Bullard, 1954].

Well, we decided to allow the full pressure

to come on the probe itself. So the pinhe it-self was filled with oil, and the recorder was full of air. And we had pressure-tight conne tions between the two, and-sort of looking back-the whole reclinique of hiting the connections through—I remember we had a good deal of trouble with getting the connections through, and eventually I decided there was too much advice in the workshop on this, and I took the end plates house. I took this home, and heated it on a gas range and soldered the connections in-little glass connecturs with a little metal skirt, and soldered Shor) Was Art Maxwell working clusely on

Bullard: He was working on this-we were buth working on the buthe making this thing. Of course, we had to make this plintegraphic recorder; you see, we had to make a plantegraphic camera and all the associated supports and things. Well, anyway, we made this apparatus in the course of about a couple of months. And we took it to sea. We had tronble in getting ship time. What we wanted was a day or two of ship those to go out and lest it, you see. We did all the testing. I remember the first testing we did, we hullt a sout of gallows down at Alission Bay [in San Diega].

which was then a marsh, of course-and strung the apparatus up with the galvanom-eter and things in it and elimbed up a ladder and cut the ropes and let it drop to see if it wunld go into the much and see whother the shock would break the galvanometer and all this kind of thing. Anyway, we theo tried without any galvanometers in to see if we could get it into the mud out in the trough off San Diego. There was a tremendous amount of sort of testing to be clone. It was

an entirely new thing really.

We discovered the trouble that if you put n thing into the bottom and left it there you couldn't avoid pulling it and bending it, and we tried tubes of various lengths and various

diameters, to see what we could de. And we more or less discovered what we could do and when we couldn't do. And finally we took it out for a con with the whole armaratus to try and measure the heat llow-and we got no reoutly at all. Everything worked. Except we didn't get any records. And we spotted what it was. It was condensation on the mirrou of the galvanometer, which we'd not thought of hebre. So we put drying equip-ment in and got tid of this. But we never got any results that summer, and I went home (to Englandf, I was director of the National Physical Lahoratory INPLA I went home and had another similar apparatus built, and I got

cesults with that. That was built of comse by the NPL workshop. We had some of the best workshop fa-cilities in the world. I was at frome. I had superb facilities and not question as to who was going to use them. You see, I was director of an operation opending many millions of dollars a year. If I said the something, they did it. And to I had proper working drawings made of the equipment and had it built in a purper workshop and so on. And we took it out and it worked every time.

Shore You rested it then off England? Bullard: Yes, I'd done all the testing here so I just made a new apparatus and took it out ia sea and it worked.

New that's all been published, so the dates on this are all known. I'll give you all the celerences. This hast paper was published in the Proceedings of the Royal Society. Van know the two letters in Nature, da you? Shur: No.

Bullard: Well, 151 berrer find these for you Revelle and Maxwell, 1952; Indiaed, 1952]. What happened was this. There was a littlewell, not exactly a mismulcistanding -bin 1 understood that the group lave and con-selves were going to publish a joint paper. And I was very basy and I held up publication of our work for some time, and evenually the [Revelle and] Maxwell letter to Nature went in, and I put a letter in in the same number. Well, then afterwards we published a joint paper [Ridlard et al., 1956]. There was a bit of a minddle alcone publication.

Bo you know-now beome to think of 0. the business about taking the thing home to make the gosthrough connection was at NPI; it was the NPL workshop that was making a some about go-through connections - pressure-right connections in heavy plates. And I rook a home and did a on my domestic gasrange. And I think this rather shook the place, to have the director take home the thing and actually do the soldering when they said they thought they couldn't do it. That was in England. It wasn't here. We did it here without any biss. We did it ourselves in the

The workshop manager was very good to us and very mee to us. And eventually, actually, some of the heavy machining was done. I said to him one day, I said, "Look, do you want us doing the heavy machining? These are hig lathes. We're not professional mechanics. We're turning considerable material, these alloy sieels. Wouldn't you rather do this puresell?" And they did-the actual onter container was machined by the workshop staff in the end. But we machined the rest of

Now there is a cromplete description—the apparatus we had here is essentially the same as the apparatus I built in England.

So that's essentially the story. And then afterwards Art Maxwell, Roger [Revelle], and I wrote a summarizing article un the whole sobject. It's a review article about heat flow. The critical things to look at are those two letters in Nature, which are the lirst publications, theo there is my paper in the Proceedings of the Royal Society describing my own measurements, and there's our joint paper with Rager.

So ended Bullard's verbal sommary in

After the onsuccessful trials of 1949, the original iostromem at Scripps Institution was discarded in layor of using thermistors in a lxidge network with an amplifier and homebuilt recorder," said Arthur E. Maxwell (personal communication, June 21, 1983). He worked with Scripps engineers James M. Smidgrass and Julin D. Isaacs on the inproved model during late 1949 and early 1950. That heat-probe was used on the Mid-pac (sometimes called Mid-Pacille) Expedi-

**Forum** 

**Global Positioning** Technology

In an otherwise excellent article ("The Impact of VLBI and GPS on Geodesy," Em. September 27, 1983, p. 569), Dr. John D. Bossler inaccurately reports that the Macrometer, a single channel receiver which came to ourker unly last year and is restricted to relative position use was the lirst global positioning system (GPS) receiver to become commercially available.

As many in the geophysics community know, Stanbard Lelectmunumications, Inc. (STI), has provided GPS receivers and ransmitters commercially for almost 5

STI dual frequency GPS Geodetic Recievers, mened and squerated by Shell, NSWC, IBM, and Draper Labs have been used in numerous absolute and relative positioning experiments. In one such esscriment, analytis of 5 hours of lune satelite phase measurements yielded relative position coordinates on a 28-km baseline which were repeatable to 30 cm in height. 5tt cm in E-W direction, and 40 cm in N-S

STI GPS recievers have been used on the North Atlantic aboard the CSS Hudon by Norrech, University of New Brunswick. and the Canadian Hydrographic Survey. Here a real time Kalmao lifter was used to combine GPS ranging and ships motion. information to update an increal naviganonal system. Further, STTs self-contained model 502B receivers provide to d. time positioning with precision on the ordecol 20 m with no postprocessing

Paul D. Pevreaub Lectoreal Staff Stanford Lelecommunications, Inc. Santa Claric, CA 93050

Lapologize to Dr. Perreault and State ford Telecommonmeations, Inc., for nolack of precision in the subject article. V. more proper statement would have been The first receiver to become commetcial Is available for continuator level our every is the Macrometer Model V-1000 Invalero

metric Surveyor, manufactured by Macto metrics, Inc., of Woburn, Massachusetts We at the National Goodetic Survey are well aware of the important role played by \$11 in the development of thy GPS we

John D. Bossler Director of Charleng and treal-he Server Rockelle, MD 20852

# Biography of Wiechert

For a biographs 1 am writing of Emil Wiechert (1862–1928), professor of genphysics at the University of Contingen. I would appreciate hearing from on realers who might have material of interest. Photos, letters, and anecdores about his life are all welcoose.

> Wilfried Schroder Hechelstrasse 8 D-2820 Borney-Rimnebeck Federal Republic of Germany

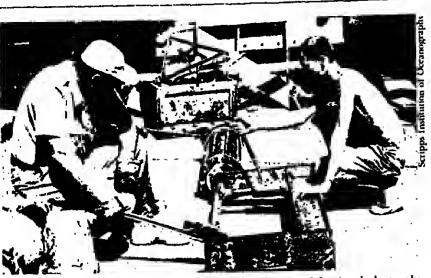
tion, carried out by the Scripps Institution of Decanography and the U.S. Naval Electronics Laboratory during the summer of 1950. (The name of this expedition is given incorrectly in Bullent (1965) as Capricorn Expedition. which was in 1952.) The last successful occanic heat-flow measurements were taken oo that expedition. (As noted to various of the early papers. Hans Petterson described occanic heat-flow measurements that he nock in 1948; Bullard rensidered these invalid.)

Bullard, as he said above, returned to England and in 1952 (or 1951)) at the National Physical Laboratory had an instrument both that was "similar to the original one" [Andland,

Article (cout. on p. 74)



Fig. 1. The heat-probe recorder built in the summer of 1949 by E. C. Bullard and



Arthur F. Maswell trightt and James M. Snodgrass straightening the heat probe after one of its lowerings on the 1950 Midpay Expedition.

#### Article cont. from p. 75

1971) It is difficult to determine from the detailed description of this instrument in that reference what modifications he and his laboratory may have made of the conginal design. Hollard obtained his best heat-probe meastrements with the NPL-built distriment in July 1952 from R 8.5. Boomery H in the At-

Maniper Ewing, at the Lamout thow Lamont-Bohertyt Geological t Oser ratorp, set out to measure field flow after using a burpowed Bullard probe in 1959 that failed to work. By 1957 Robert Greated and Fwing had developed a needle-probe device for measuring hear flow that was anashed to the tonfinely used pistons once (Gerard et al., 1962).

What was ween spring about those early occante measurements of heat flow? As Hulland (1965) charmogly recompred in the historical attention nor to bre's look, Textestant Heat Phys. two continuents of the British Associaman lan alor Advancement of Science, 1900 III 1868 and one in 1935, had been appointed "no consider" underground (connectiones and thermal combiners members. Bullard conducted name of the experimental work for the 1933 committee, and, typically for whatever he was doing, he because intogreed by the breadth of the subject. What might be different about the deep or earth

The scale of the are was sommarized in the Bullard et al. (1950) paper.

. there are only a few dozen reliable measurements of heat flow on the contiments. The values range between 0.5 and 3. peal aniser an most of them being between 0.8 and 1.1. The mean is about 1.2. matemiser.

The continental heat flow is easily avcompact for in the radioactivity of the contimental rocks . Some a large part of the material above the Mohorovicie discoming its aca depth of about 35 km must be grante or similar tooks, and since some heat most come from below the discommo ity, the ditherdry is not so outsh to had a somer for the observed heat as to explain which the flow is not greater than it is . . .

The periodogical study of oceanic rocks and seemological work at sea have shown that the cross beneath the ocean basins is strikingly different from that underlying

In sies of the striking differences in petrology and structure between the ocean and the continents it might be expected that the bear flowing front die oceans would be only a traction of that Isom bemeath the contineors. In fact this is not so Since the ocsaw cover 71% of the

earths surface, a reliable a simuly of the amount of heat flooring through their thous is of great unportance in discussions of the control thermal history. The oceanic the continents are not, however, merely an the finalitisms of differences between the or caus and the comments the heat flow at tra piece i problem separate from that of

framediately after the Midpac Expedimon. Results wrote to Rulland d Scrober 15, 1950; carbon of herry to matchises of the Scripps Instrument makes Expediments Malpage

We managed to get at feast seven good toramien ents of temperature gradients in the bettero made All bus one of these inthsate a gradient atomid to \$2.1° per metro. \$1 your conditionals remaines can be used, this means that the heat flow Isom the sea-Boo is the same as that boost the contiterms. To me, at least, this is a very susprisong result for apparently you dyly susperi-एने में औं तह बाहू.

Rodinal Monett [1932], in their letter in Nature, effect six succentrements, with the orinments "It is noteworthy that at live of the six healther meeting a total distance of nearly three thousand miles, the computed heat flow her within 100 per cent of the average value.

Bullard [1952]. It the letter to Nature, said that the communication by Revelle and Maxi-

well [from the Midpar Expedition] gires a result which is completely unexpected, and demonstrates again how little we know of

submarine geology."

When Bullard first converned birdself with measuring the flow of heat through the occan floor in 1939 and had the opportunity at Scripps Institution in 1949, the fectonic deman ation between land and sea to geologists was sharp. Every bit of evidence was needed to auderstand the whole earth. As measurements accumulated, patterns of variation in hear flow through the ocean floor began by emerge, and realers of magnitude for "average" values improved. Laugeth and Von Her-2m [1970, p. 200] much that "a surface flux of up to eight times the earth's average is observed near the axis of the mid-oceanic

Those early heat-probe measurements, aropired with "a very clumsy apparatus" that began in Bullard's mind and hands, contribmed considerably to the global knowledge of inday's genultysicists.

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# Edward C. Bullard 1907-1980

Protesya Sir Eshvard Bullard was bonored hy lite Oncen in 1975 as a "world leader in geophysics." Earli of those words is ant: world"-because indeed the earth was his domain, in theory and field work, in cir

and remove regions, and at sea: "leader"---because after listening to and contensing with students and colleagues he volged them toward carrying onclarge ideas

From half-loroied thoughts: "geophysics": - a beld between prerise physics and imprecise geology that came into bemg only because a lew outstanding and versatile scientists like Bullard could span the

"Chance led rur into geophysics at a won-alerful time," he said, "and it has been among the most rewarding experiences of my life to trase played a part to the translormation of a ten kwiner into a bandwigon" [Hollard.

Tedds Bullard carried this off with a unique charge, with a near-Purkish huntor. and with an interest in people that made every clear with him memorable and every lecture by him a keen delight. His legacy will prince to be more than his two considerable scientific endeasors; it will include the accomishments of his students and colleagues and a better effort even by his casual acquaint-ances. It has been said: "The thing looked s simple when Teddy explained it, it was only later you realized how deeply he understoo

He was an outgoing man, quite lacking in pomposity, yet very aware of status in his acintances. He observed the differences but never made invidious comparisons between his homeland and his adopted home country. Although he appeared disinterested in hon-

ors, one sensed that they pleased him. falward Crisp Bulland was harn on September 21, 1907, in Norwich, England, where his lather's family were brewers. In his early years he was not an ourstanding student, but luring high-school years he developed a keen interest in physics through a texcher. He eutered Clare College, Cambridge, and graduated with first-class honors in physics. In 1929 he became a graduate student in the Cavendish Lahoratury of Lord Rotherford, from which he received his Ph.D. in 1932 with a dissenation on the scattering of slow electrons in gases.

The hist position available to the young physicist in those rlepression years was for the Department of Gendesy and Geophysics at Cambridge, as a demonstrator in surreying. As such, according to Bullard (who wrote a tribute to himself at the request of Walter Munks, he "embarked on a very profitable eight years in which he learned the elements of Earth science and carried out a remarkably rliverse series of projects. The success of these was in large part due to the steady sup-port of [Chlonel Sir Gerald] Lenox-Conyngham, who was not at all disturbed when told that the police were looking for the perpetrators of an explusion which had left a ule in a road in Leicestershire" (Munh,

The lirst in the diverse series of projects was measuring small variations in gravity, for which Bullard developed an elegant technique for timing the swings of an invariant ululan. The work was done during 1933-1934 in the East African Rift Valley, where on one occasion he and his wife Margaret were treed by a lion.

The explosion that disturbed the police was part ni a grimp program to man the Paleoznic layer beneath eastern England by means of seismic refraction. At the 1936 meeting of the International Union of Geodesy and Geophysics in Edinburgh, Bullard met Princeton enlingist Richard M. Field. It was Field's insistent theme that geologists must study the ocean finer. Bullard [1975a] said: "He would not take no for an answer, he would not stop talking, he had no doubts, he was embarrass ing and sometimes a muisance, and yet he struck the match that set earth science alight

. He invited me to the United States in 1937 ... and sent rue out to sea trith the Coast and Geodetic Survey and with Maurice Ewing," Upon his return to England, Bullard began seismic studies with Thomas F. Gaskell in the western approaches to the English Channel aboard two Brixham sailing trawlers.

As a third renture into the young field of geophysics, Bullard measured the temperaarre gradient, or heat thuy, on land in England and in South Africa in 1938-1939. This was for a committee of the British Associating for the Advancement of Science, appointed in 1935. Work of this kind, said Bulard once, "had been done extraordinarily bailly before" [Shor, 1984], and elsewhere he noted: "Great difficulty was experienced in finding suitable (hore)holes, but very satisfactory resolts were chazined from those that were found" [Bulland, 1965]. The project led Bullard to pondering a means of measuring

heat flow in the deep ocean. On the advent of World War H. Bullard become an Experimental Officer in the Naval Scientific Service, first to develop methods for protecting ships from magnetic mines, then to develop methods for sweeping acoustic and magnetic mines. He moved on to intelligence investigations pertaining to the German development of rockels and to a stridy of the most economical ways of attacking hring sites in France. The Times noted that Bullard "heilt on around him an asconshingh rersatile and effective establishment which, in the argency of time, had when necessary, an utter disregard for the formalities



At the change of command in 1976, the lbatross Award of the American Miscelaneous Society was transferred to Edward C. Bullard (right) from Roger Revelle (left). It's a scruffy bird, but a signal honor,

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of normal civil service rules, and thus moved with a speed impossible for other establishments" [Abittheun, 1980]. His participation in matters for the Ministry of Defence continnerl for many years, and he served on the romultee for a nuclear-test han treaty also.

Bullard remrued to Cambridge in 1945, where he insuid the laboratory in a shambles after if years of disose, but he gut it into operation and suns became head of the Department of Genphysics. The lack of research fitteds and lack of access to a research ship frograted him to the extent that in 1948 he accepted the position as hearl of the Physics Department at the University of Toronto in Canarla. There he initiated theoretical inquiries into the source of the earth's magnetic field, using the early computer system ACE. Bollard's long-pursued work on dynamo theore of the earth's core constitutes his most ofound single contribution to knowledge of

In 1950 Bullard returned to England to succeed Sir Charles Darwin [grandson of the author of The Origin of Species) as Director of the National Physical Laboratory at Teddington. While chafing some at the cesponsibilities, he felt that he was an effective director, and he was able to do a substantial amount of his own researches. In fact, "through his posttion as director he was able to deploy the entire resources (by no means inconsiderable) of the computing division to carry out extensive numerical work required for the develop-ment of his [dynamo] theory" [Massey, 1980]. The position and his competence gained him a knighthood in 1953.

Bullard in 1956 resolved his indecision about what kind of life he wanted by returning to Cambridge, again as head of the Department of Geodesy and Geophysics. There e felt diat his primary commitment was to his own work and to helping a large number of very able graduate students. It was an era ferment in the expanding field of geophysics, and Cambridge became a focal point. In 1968, for instance, Harry Hess, J. Tuzo Wilson, Drimmond Manheivs, and Fred Vine were all as Cambridge, and Bullard was reassembling the continents by computer with deceptive simplicity [Bullard, 1964]. Seafloor spreading and plate tectonics were launched, and for those theories Teddy Bullard was a primare catalyst.

In his Cambridge years he also directed a major investigation into electromagnetic induction in the earth; he helped in establishing the technique of determining the age n rocks by the potassium-argon method; and he encouraged the application of modern compater techniques to geophysical problems. Always he was interested in the history of science, and he assembled a considerable library in it. This seemed to be an nutgrowth of his interest in people: for an individual's memorial account he wanted to know not only the science but also the minutest details of that person's life. He quite enjoyed writing historial summaries of aspects of geophysics.

Bullard's association with Scripps Institu-tion of Oceanography in La Jolla, California, began with a brief visit in 1948, followed by a 2-month stay in 1949 when his hest heatprobe was developed [Shor, 1984]. From the mid-1950's he was a frequent risitor to Scripps, trhere from 1963 to 1977 he held a part-time appointment as professor of geo-physics. When he cetired from Cambridge in 1974, he ninved to Lit Julia permanently. There he continued to work vigorously on what he called "his favorite topics of plate tectonics and the origin of the Earth's magnetic field," and he was drawn into an adrisory role to the U.S. government on nuclearwaste disposal. In all, he published some 200 papers (a memorial account and a complete iography will be published by the Royal Society of London).

Bullard married Margaret Ellen Thomas in 1931; they had four daughters. Margaret was the ambor of several novels situated in various places where the family had lived. In-1974, Bullard married Utsula Margery Curnow of New Zealand; she is an accomplished painter and sculptor.

This giant in geophysics dierl of cancer no April 3, 1980, in La Tolla, Only a tew before his death he approved final changes on the paper "Direction of the earth's magnetic field in London, 1570-1975," with Staart Malin of Edinburgh. Teddy made life in-teresting, and he faced death with courage.

#### Awards to Edward C. Bullard

Sedgwick Prize, (938

Fellow, Royal Society of Landon, 1941 Hogles Medal, Royalty Society of Landon, 1953 Foreign Honorary member, American Academy of Ans and Sciences, 1954 Chree Medal, Physics Society, (956 Furely: Associate, National Academy of Sciences. Day Medal, Geological Society of America, 1969 Gold Medal, Royal Antronomical Society, 1965 Agassiz Medal, National Academy of Sciences, 1965 Voltation Medal, Genlogical Society of London. Cellesen Medal and Prize, Columbia University. Royal Medal, Royal Society of London, 1975 Sowie Medal, American Geophysical Union, (975)

Maurice Ewing Medal, American Geophysical Unlan, 1978 The facilities of the Cambridge Department of Geodesy and Geophysics were named the Bullard Laboratorios in 1980.

tross Award, American Miscellatteous Society,

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This tribute was contributed by Elizabeth N. Shor, La Jolla, CA 92037.

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Cover. This weak-beam micrograph shows a twist boundary in an experimentally deformed olivine single crystal from San Carlos (Arizona). It was taken with a 125 KeV transmission electron microscope. The scale bar is 2200 nm. Such or thogonal arrays of screw dislocations are also commonly observed in naturally deformed peridoties. They are produced during deformation or annealing events either in the earth's mande or during ascent of the olivine-bearing hotlies to the surface. The micrograph was taken by Daniel L. Riemilt fadvisor: D.L. Kohlstedtl. Department of Materials Science and Engineering, Curnell University, Itha ra, New York

#### An Invitation

Would you like to be on the cover of Bas? If you have any illustrations with both aesthetic charm and scientific interest-photographs (preferably black and white) of geophysical phenumena, experi-niental results, or graphs—Eor would like to consider them for publication on the cover. Searl the original illustration of g x 10 inch (20 x 25 cm) glossy photo with a short (50-200 words) explanation that can serve as a caption. You may also subfilt a more extensive news tiem or even a short article in accompany a proposed cover. Captions will be by-lined. If the material has been previously published, please supply a copyright release from the copyright owner. Send it to Eas Cover, AGU, 2000. Florida Avelue, N.W., Washington, DC 20009.

# Cretaceous Boundary

Four years after it was hist proposed, the theory that a tolossal meterrite struck the earth 65 million years ago confintes to build toward a consensus-this respite recent hadings that enleanic eruptions might also have caused the "iridium anomaly" that is the impact theory's best evidence (Eps. February 7, 984, p. 41). High concentrations of iridium at the Cre-

taceous-Tertiary houndary were first notired in sediments from Italy, Denmark, Spain, and other locations around the world by Walter Alvarez, his father Luis, and their Berkeley colleagues. They concluded that the source of the extra iriditim must have been extra-terrestrial because the element shows up in crustal rocks only in very small amounts and no one could think of a merhanism that would distribute tridings from the mantle so wirlely around the surface of the glube. The Alvarez group posmitated that a nicteorite about Rickin wide had collided with the earth, throwing up a planet-encircling cloud that blocked mm sunlight, ended photosynthesis, and suffed out many of the land and sea creatures of the Mesozoic, including the

Until recently, the iridium anomaly was virmally the only support for this idea. In Noreinber, however, two researchers from Yale University, Jean-Mart Lank and Karl Turekian, reported what may be even more conpelling cridence. They analyzed osminn isotopes in boundary-layer rocks from Henmark and Colorado-osminu is another platinumgroup metal that shows up anomal misly high in these sediments—and found nearly cond amounts of 187Os and 186Os, an isotopic ratio much more characteristic of meteorites than of crustal rocks, tank and Truckian had her In pothesized that if a normal geochemical process such as precipitation from wawater gad conventrated the osminus they would see the higher ratio found in terresulal rocks. After examining a number of occanic manganese todales, they bound that this was indeed the case, and so concluded that it was a meteneity impact (or possible two impacts, since thee found different ratios at the two sites) that deposited the ounium

With this new information, is there gow a consensus on the ineteorite theory? Not yet. says Charles Orth of the Los Alamos National Lahoratore, who provided Eack and Tirrekian with the sample from Calorado's Raton Sasin and who was the first to find the iridimn anomale in freshwater sediments, "Wecan't yet lar no rest a volcanir source - we need to learn more about the platinum recial ratios in the mantle." Recent limbings at Kilauca in Hawaii show that iridium can be crucentrated on the surface after settling unit from volcanic emissions. It would have required an enormous explosion to rhistribute this rolcanic material globally in the Cretaceons-Terriary boundary layer, however, and the sort of slow, onzing flows that normally accompany emptions like Kilanea are not Consistent with this.

Most frigurating of all bir the incremite-theory faithful is the continuing lack of any evidence of an impact. So lar, about 100 staters around the world have been evaluated as passible cambidates, according to Thomas ]. Abreus of the California Institute of Technologe, "but name wern no be the right size and " For this reason, many people favored the idea of an orean impact right from the start. After all, Ahrens points out, the climate was warmer bå million yearv ago, warer wasn't birked up in pidar ice caps, and there was more occan.

An orean impact would also explain why no crater has been identified-more than half the arran floor that existed 65 million years. agreis gone, subdimined back into the mainle. Furthermore, recent repeats of small spherolds that appear to be altered "impact shoplers" of basaltic origin (found in boundary layer rlays in northern bale and the rentral Pacific by Alessandro Montanari and colleagues at Herkeley) make the case for a seafloor impact even stronger. But where are the remnants of the great ismumits and submarine landslides that would have followed such an event? No one has yet come up with

Meanwhile, Charles Orde and others are looking for iridium appenalies at other periods in geologic history. This leads to another question: If meteorites do a vasionally bit the earth, are they responsible for mass extingtions: Doth and various coincestivators have checked for high initions concentrations in clars known to be deposited during other preriods at wholesale extinctions, including two trilobite-brachiopod boundaries in the late Cambrian, where they bound no iriding anomaly. Orth has also checked boundary layers from the Ondovician-Silurian and the late Desonian. No amountains there, either, But he continues to search for other examples of infidition excess across time and plans to widen the geographic range of his studies of the Cretaceous-Tertiary boundary layer to establish a more alokal pattern.

Walter Alvarez, with whom it all started. will have a paper in Science next month in which he counters the counterarginoem that the extinctions at the end of the Mesognic were gradual and so condition have been caused by one coastrophic event. Alvarez and his coauthors, based on a review of the existing paleontological literature, see "a sharpdropall" eight at the iridinm-rich boundary layer for hour groups of marine fovertebrates: ammunites, one group of la vozoaus. brachiopods, and bivalves. "Some paleontakegists have said that the dropadls were more gradual," Alvarez told Eas, "but we looked back at the record, rather than what ther say the record shows."-TR



## Planetary Science Budget

The liscal year 1985 budget for the solar system exploration program of the National Aeronautics and Space Administration (NASA) is very promising (m/5Eos. February 14, 1984, p. 491. As announced by the Office of Management and Burlget, the document includes a new start-up program for the MGCO Mars Geomience Climatology Orbiter) mission. Mixed in with the set of encouraging figures of NASA's Space Science and Applications budget plan, unfortunately, is the more oncertain area of funding that includes support for the Research and Analysis program. These programs seem to be less visible in the budget, but they include important components of the space science program. A large portion of these funds is provided to university scientists to support research at the righest levels of excellence.

In a recent letter to members of the academic scientific community, William L. Quaide, chief scientist of NASA's Solar System Exploration Division, expressed a unte of uncertainty and caution about the fiscal year 1985 budget operating leel for the Research and Analysis programs. According to Quaide: The reduction in [Research and Analysis] funds will require that we abandon, temp rarily, plans to address all the problems that are facing us, and concentrate nur support rin a few specific areas to preserve sumecrutimity of participation and to maintain connabilities for future missions."

Quaide pointed out that an augmentation of \$15 million will be needed to maintain the support level of funding realized by the listed 1984 appropriation. Indeed, an augmentatinn for the research and analysis program is included in the president's budget, but only hi the amount of \$6 million. Conceivably that number could be increased by Congress if the, need were made known.-PAIR

# Titan Ocean: Ethane, Methane, Nitrogen

Detection of the atmosphere of Saturn's satellite Titan by the Voyager I spacecraft in-dicated an abundance of only 3 mol % meth-ane (CH4). Recently J. 1. Lunine, D. J. Stevenson; and V. L. Yung calculated that 3 mol % melhane is sufficiently low to proclode the stoble coexistence of liquid methane on Titan's surface, which has a temperature of 94 K (Scieuce, 222, 1229, 1988). Instead, Lunine et al. suggest that Tiran's atmospheric meth-

photorbenneal reaction to erhant (CgHo). The resulting organ would consist of a tinxture of Calls and Clin in the proportion of 3

The dissociation steps of Galls involve lors of hydrogen be escape, making the process irrerersible. The postulared ser reactions are: 2CH<sub>1</sub> → C<sub>2</sub>H<sub>2</sub> + H<sub>2</sub> and 2CFh → C<sub>2</sub>H<sub>3</sub> + 2H. The intermediate molecule Calla plans the role of catalysis and shielding of Calls from photolysis. C.H. is calculated as being broken down in 'fitan's atmosphere at a rate of 1.5 x 10th cm2 st. The evolved H and Ha would leave the exosphere at rates of 5.5 x  $10^{\circ}$  and  $7.2 \times 10^{\circ}$  cm<sup>2</sup> S<sup>3</sup> respectively. The result is the production of an ethane-rich ocean of I kin depth. The composition of Titan's present ocean was deducer! from calcus of the C.H .- CH ., N2-CH ., and N2-C2Ha binary systems. The be consistent with Voyager observations, it was noted that the existence of several percent propane in the ocean would be compatible with the calculat-ed proportions. The calculations also include a 100-200 km thick layer of solid CaHe on

Titan's ocean floor. What is larking to make a case for an ethane-rich ocean is mute observational data. Lunine et al. note that important tests of the model are verification of the existence of CHe clouds with the correct opacity, detection of CoHa saturation of the lower troposphere, and radar evidence of an ocean.—PMB

## Alaskan Transect

A compensive geophysical/geologic transect rd the Alaskan cross and upper mantle is being organized by the U.S. Geological Survey (USGS), the Alaska Division of Geological and Grophysical Surveys (ADGGS), the Unireisity of Alaska, and Rire University. The roject is to be known as the Trans-Alaska Lithusphere Investigation (TALI). The rrute of TALI lies along the north-south corridor of the mans-Maska oil pipelite between Prodhoe Bay and Valdez and extends offshore across the Pacific and Arctic continental mor gins. The transect will Incorporate several applementary probles intersecting the primary route. TALI is envisaged as a coordinated multidisciplinary ellort anonny government, hearleinic and Industry scientists and

To prepare a prospectus for the transect, a workshop will be held in Anclurage on May 29 prior to the meeting of the Seismological Society of America and the Corollileran Section of the Geological Society of America. (May 30-June 1). The National Science . Foundation is co-sponsoring the workshop.
Some of the studies that will constitute its portant elements of TALI are under way rir

will be initiated this year. Rio, University and the University of Maska are engaged in a cooperative study of the kinematics of thetorius from it the Brooks Range, ADGGS and 1 868. will somitime geologic mapping and myesigations in various areas along or near the transect route. To help launch TALL the USOS will start this smanner its frants-Alaska tarnstal Transect (FACT) project to investigate the structure and evolution of the reast, using scismic refraction/reflection, geologic, gravitt and magnetic techniques. The TACT project will begin along the southern anshore svgment of the transect, between Valdez and thy Alaska Range; several investigatory fram other institutions will be directly involved. Other institutions, including Cornell University (COCORP), Lamour-Dicherty Geological Observatory, and the University of Utah are exdoring participation in TAL1 in 1985 and arer years. The goal is to complete the transect by the end of this decade.

Geologists and geophysicists interested in participating in TALI or the May workshop should contact: Robert Page, U.S. Geological Survey, Mail Stop 77, 345 Middle/teld Rd., Mento Park, CA 94025 (415-324-8111); ur. John Davies, Alaska Division of Geological and Geophysical Surveys (907-474-6166), or David Stone, University of Alaska (2017-474-7022), both at the Geophysical Institute. Unirersity of Alaska, Fairbanks, AK 99701.

This news them was contributed by Robert A. Page, who is with the U.S. Geological Survey,

# Geophysicists

Two AGU members received Fullyight scholarships for 1983-1984; John R. Holloway, professor of chemistry at Arizona State University, will be working in Australia. Teh-Lung Ku, prinfessin of geological sciences at the University of Southern California, will be working in France.

#### In diemortum

The following AGU members are recently deceased. Their AGII section alltimion and year of joining AGU are shown. faime Amorocho, 64. An AGU Fellow, Hydrology, joined 1952.

Grover B. Grisp, 13, on April 20, 1983. Geudesy, joined 1980. Mahdi Salih Hantush, 63, on January 14, 1984. Hydrology, joined 1949.

Allen A. Jergius, 80. Scismobygy, joined

Jack H. Meek, 66, on October 12, 1983. Soar Planetary Relationships, inined 1959. Helnz G. Poetaschke, 68. in November 1983.

Geodesy, joined 1976.

#### The Boundary Integral **Equation Method for** Porous Media Flow

James A. Liggert and Phillip L.-F. List, Allen and Unwin, New York, 1983, xi + 255 pp.

Reviewed by Mary P. Anderson

Just as groundwater hydrologists are breathing sighs of relief after the exertions of learning the finite element method, a new reclinique has reared its modes—the boundary integral equation method (B1EM) or the boundary equation method (BEM), as it is sometimes called. As Liggett and Liu put it in the preface to The Boundary Integral Equation Method for Possur Metho Flow, "Lately, the Boundary Integral Equation Method (BIEM) has emerged as a contender in the computation Derliy." In fact, in July 1984, the fith International Conference on Boundary Element Methods in Engineering will be held aboard the Queen Ehzabeth II, en mute from Southampton to New York. These conferences are sponsured by the Department of Civil Engineering at Southampton (UK), whose members are proponents of BTEM. The conferences bave leatured papers us applications of BIEM to all asperts of engineering, includ-ing flaw through parous media. Published proceedings are available, as are textbooks on application of MEM to engineering prob-letus. There is even a 10-minute film on the The applications of BTEM to flow through

purous media are explored by the other maor proportions of this method in this text-book by Liggett and Liu of fornell Universi-ty, Briefly, BIEM involves an application of Green's formula, which allows the dimensionality of a problem to be reduced. The methral consists of planing moder on the boundaries of the domain -- a line for 2-dimensional problems, an area for 3-dimensional probems—and integrating over the houndary. Then application of Green's formula makes it possible to solve for the head at any point in the interior of the domain. The catch is that it is occessary to know both heads and their mornal derivatives along the boundary. Forrimately it is possible to derire an expression relating head along the boundary or its nor-

mal derivative, so that given either head or its derivative, it will be possible to solve for the other at each nucle. An arlyantage of the method is that any approximation involved in discretization is limited to the boundary, although there is a boundary layer effect causing leads near the boundary to be more subject to numerical errors than heads in the interior of the rlomain. Liggett and Liu suggest that the thickness of this boundary layer is approximately equal to the length of a

boundary element. The book is written at an advanced level and requires a thorough familiarity with calculus as well as the theory of flow through porous media and finite element techniques. The examples used to illustrate the use of the BIEM reflect the training of the authors, in that classical engineering problems in flow through porous media are emphasized including flow through dams, flow acound a cut-uff wall, flow to wells, seepage from a poud, and rectarge from circular and rectargular regions.

A mathematically compact introductory chapter reviews the basic theory of flow through porous media and the relevant governing equations and serves to introduce the reader in the authors' notation. Chapter 2 describes the application of the method to simple problems involving Laplace's equation and linear interpolation of head between boundary under (linear boundary elements). Chanter 3 deals with more sophisticated interpolation schemes, known as special elements. Chapter 3 also introduces a nowerful feature of the method, whereby infinite domalus ran be treated by using an analytical solution to construct a special element to extend the problem domain from the near-field solution, where a detailed solution is desired. out to infinity. In this way the problem of delining nearlichl boundary conditions is avoid-

BIEM treats heterogenelty by dividing the problem domain into several humogeneous zones. The concept of zones and the equation manipulation (by stretching the coordinate system required to treat anisotropy are dis-cussed in Chapter 4. Chapter 5 describes the solution of transient free-surface problems using steady state governing equations and transient boundary conditions on the Irce surface. Chapter fi rleals with axial symmetric flow problems, including recharge from circular areas and flow to wells. Chapter 7 deals with 3-dimensional solutions of Laplace's

equation applied to well problems and to unronfined aquifers using a transient boundary condition on the free surface. Chapter & discusses the application of BIEM in problems involving a sharp interface between two linids, e.g., salt water intrusion without dispersion. Chapter 9 focuses on the intriguing way in which boundary elements can be combined with standard finite elements. It is clear that a finite element approximation is more appropriate for heterogeneous problems. Huwever, if only a portion of the problem dinmain is heterogeneous, it may be advantageous to

use boundary elements for the nonheterngeneous portion. Examples presented in chapter 9 include unsaturated-saturated problems, in which finite elements are used for the unsaturated zone and boundary elements are used for a homogeneous saturated zone. Throughout chapters 2-9, the results of the BIEM are compared to analytical solutions and to results of finite difference and finite element solutions drawn from the litera-

Chapter 10, the longest in the bonk, discusses the application of BIEM to problems involving regional groundwater basins includ-ing leaky aquifers. The problems are bandled using a quasi 3-dimensional approach, where by flow through aquifers is assumed to be horizontal and flow through confining beds is assumed to be vertical. Reference is made to a computer code called GM5, which was used to simulate the Yun-Lin aquifer in Taiwan. Ottout from the simulation is presented but the code is not, owing to space limitations. However, sample FORTRAN codes are presented in chapter 11. The code GM8 solves the Laplace equation using linear elements; GM9 is an extension of GM8 that allows for the use of special elements; and the program DAM solves transient free surface flow through a dam of constant hydraulic couducivity. In addition to the codes, documentation of input as well as sample input and output data sets are presented. An appendix containing a list of symbols used in the bank

and discussion of some of the finer mathemuical points is also provided. The authors succeed in presenting a conrincing case for the utility of IIIEM for certain types of engineering problems in Ilnw through porous media. Yet the book's bibliography gives unly a lew references on applications of BIEM to flow through porous media and these are largely papers by Liggett in Lin. Hence, one is left wondering why the

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method securingly has not raught on among specialists. The arrenal of mathematics peeded to understand and program BIEM rivals the limite chement method, and as a result BIEM is unlikely to take bull among "the masses" until the documentation and release of general "rannerl" programs similar to the one discussed in chapter 10. Still, the book is a good start in luninging BIEM to the atention of groundwater hydrologists and will be especially useful to those who already have a working knowledge of tunite elements and who have occasion to solve those classes of

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Program Manager-Alr-Sea Interaction. NASA Headquarters' Oceanic Processes Brainly is seeking candidates for planning, the cologing and implementing a schedule research program indizing safetive rectining to under general area of an sea unceration. Specifically in toded is the use of satellite scattering the transfer of surface would teld, and the effect of surface winds on upper securions to challenging the Padulty Recommunity. os Qualitications inclinde Italielis to communicate effectively. 2) demonstrated experience in con-ducting original review I. O program management experience, and I benowledge of physical recomog-raphy, US-1 CDs, with solary ranges from \$11,277 for 50.5.15, confine naive with experience behavior for bother information in garding requirements and application prescribers with to address behavior plone 202,775-805; Format applications must be received to May 6, 1984. NASA Headspariers, Code NBP, Washington, D.C. An equal opportunity expulses

Foculty Position/UCLA. The bepartment of Farth and Space Sciences, 1711 A, weaks applications for a regular Licidity position in the area of sectimental cycle, welcomentary petrologi, farm analysis, iteatigaphys, and reprint geology. A Ph.D. or equivalent is required. There is no restriction as to the level. Dimer will include ninlergraduate and graduate reactions, suggestion of theses and dissertations, and development of a retract h program in the area of specialization. Field-land experience will be factor into consulteration. The experience will be factor into consulteration. The appointment will begin not later than January I, 1985, and may begin as wour as July 1, 1981. It will be full-time, rincergonally tenue or tenure task. Sciul resome negal as work as just 1, 1981. It will be full-lune, nine-month, tenthe or tenthe track. Send reasone in: Dr. William M. Kaula, Chalman, Department of Earth and Space Sciences, University of California, 405 Hilgard Arenue, Los Angeles, CA 19024.

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University of Colorado-Boulder—Tenure Track
Position in Atmospheric Dynamics. The Repartment of Astrophysical, Planetary and Atmospheric Sciences (Icalien) states to options in other leads to mospheric science. The sime solution in the field of atmospheric science. The sime solution applications for a remore track family position in the field of atmospheric science. The sime solution applications are the first degree and should prosess a strong background in grouphysical fluid distrants or distribute the arrow of training the strong background in grouphysical fluid distrants or distribute the appointment will be at the assistant protessor feed tallibough fire assistant and spile from Angust 29, 1984.

Applicants should have a strong commitment to research and to teaching at the graduate and undergraduate feed. The upportunity will exist for a formal association with the Laboratory for Atmospheric and Spile Physics, which having ong programs of space observations of the transmitters of the references to:

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Planetary Geologist/Geophysicisti Jet Propulsion Laboratory, Earth & Spaco Sciences Division. The Planetary and Cheaningraphy Section and hearty the availability of one or two Cultime, stall scientifices. availability of one or two failitine, stall wiemin research positions in the areas of planetary grobust and grophysists. The early of appointment is open, but applicants dioubil be beyond the position and level total a demonstrated tecord of expective and accomplish mems in independent research and publication. We will come applications as applied in the study of study-looky planets and natural satellites with emphasis on determining surface properties and processes on planetary objects using ground-love and spacetal remote sensing data and applicable theoretical and experimental techniques. Applicants should send letter unduring their experiment, professional guals, freume, and tripies of periment publications to: Dr. William R. Wani, Manager, Planetology and Oceanography Sertion, jet Propulstion Laborators, 48th Oak Grive Dive, Dept 1.54. Mail Stup 249-184, Pavadena, CA 91103.

Postdoctoral Position/Dalbousie University

Postdoctoral Position/Dalbousie University. A twi-sear position in the Oceanography Department is available fire a person interested in marine goophydes. Specific work involves participation in heat flow studies across the margins of castern Canada but broader upportunities also exist for self-motivated projects within the University or at Bedford Institute of Oceanography. A Ph.D. in geophysics and device to work 1-2 mostyr at sea are regolved. Experience with heat flow helpful but not exsential. Send. C.V. and names of two references to: De. K. E. Louden, Dept. of Oceanography, Dalbousie University of the project of Oceanography, Dalbousie University. Louden, Dept. of Oceanugraphy, Dalhousie Univer-ity, Halifax, NS, Canada, BSH 4]1.

Research Position in Space Plasma and Auroral Physics. Two research positions at the level of avsisiant or associate research scientists are available in the Department of Physics & Astronomy at the University of fowa for qualified candidates with a Ph.13. degree and experience in spare plasmas and/or auroral physics. Present research in space plasma physics emphasizes snalysis and interpretation of observations of magnetospheric plasmas using instrumentation on board earth-orbiting spacecualt in the IMP and ISEE Missiums. The University of luwars global imaging instrumentation on the spacecraft Dynamics Explorer 1 is the source of an extrusive data base of auroral images from high altitudes at visible and utraviolet wavelengths. Plustumentic observations are also available for other areas of research including the physics of the upper attunsphere and the global distribution of intuospheric ozone. The applicant should identify and describe areas of his or his expertise which can support experimental or theoretical investigations in space plasma physics and/or suroral physics. Salary unit position will be determined by the applicant's qualifications and experience.

A resume and the names of three persons Lough.

plaina physics and/or suroral physics. Salary mul-position will be determined by the applicant's quali-fications and experience.

A resume and the names of three persons knowledgeable of applicant's experience should be for-warded to: L. A. Frank, Department of Physics & Astronomy, University of Iowa, Van Allen Hall, lowa 13ty, Iowa 52242.

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Geophyalelat/University of Minnesota. The Department of Geology & Geophysics Invites applications for a tenure track position in solid-earth geophysics beginning fall 1984. We seek a Ph.D. and preferably some postdoctoral experience. The field ul interest is open but include for constalled.

preferably some postdoctocal experience. The field ul interest is open but includes, for example, gravity/magnetics, global and regional tectonics and the physical state of the crust and otanile.

Pretent research programs in geophysics include geomagnetism and paleormagnetism, mineral physics at high pressures, and cruttal seismology. We also emphasize the interconnectedness of geophysics with the in-house strong programs in auqueous and isotopic geochemistry, tectonics, and limnology. Please submit a letter of application and attach a ctaricidum vitae, statement of research and teaching interests, a list of publications and the names of three to live references by March 15, 1984 to: Subir Bancrice, Department of Geology and Geophysics, Minneapolis, MN 55455.

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Environmental Sciences Director. Growth opportunity to tranage a division dedicated to environmental social sechnology development and midgation, emphasizing innovative lossi energy recovery; Required is a PhD or equivalent plus 10 years related research and leadership/management accomplishment. Location in Rocky Mountains on University of Wyoming campus offers excellent quality of the outdoor recreation, university, small community oriented. Send credentials including salary requirements to Manager of Personnel Services, WESTERN RESEARCH INSTITUTE: P.O. Box 3395, University Station, Laramie, WY 83071. WRI Is an equal opportunity employer.

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Cosmochemistry Faculty Position/University of Arizons. The Department of Planetary Sciences and the Lunar and Planetary Laboratory invite applications for a state funded, tenure track position in Cosmochemistry. The area of specialization which in Cosmochemistry is open. The appointment involves research, teaching, and the supervision of graduate sturients. The auccessful candidate will be either at a junior level with extraordinary promises. research, teaching, and the superior of gradune aurhents. The auccessful condidate will be cliher at a junior level with extraordinary prosise, of acientific accumplishment, as well as the potential for developing substantial leadership, eapabilities and an international scientific reputation or will be and an international scientific reputation or will be an a senior level having alrendy demonstrated decident as a senior level having alrendy demonstrated decident as a senior level having alrendy demonstrated decident as senior level having alrendy demonstrated decident as solitable candidate can be identified. Applications will be eccepted at least ontil May level, applications including a resume and the named and acceptable candidates are identified. Application, including a resume and the named and acceptable as refer dresses of four individuals who could serve as refer dresses, should be sent for Professor Eugene H. Leyr. Head, Department of Planciary Sciences. University of Arizona, Tucson, AZ 85721.

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Symposium on Meteorology and Oceanography of North Americo High Lattitudes. A Symposium on Meteorology and Urecarrography of Northern High Latitudes will be held Uriotar 3-5, 1984, in America age, Alaska. I for moreting will be responsived by the America on Meteorological Staticty and the AAAS, and will be held to conjunction with the Alaskan Science Conference.

Papers are will inclour all aspects of frigh latitude metrocology and organization, although the foats will be on time wafes ranging from less than a day to several months. Sessions are planned on the following toples: altered for interaction in the high latitudes of the North Pachte; bongrange forecasting for the Alaskan region; meteorological aspects of alterdulus in the Far North, with special confunction the Fairbanks region; and the variability and predictudility of sea he conditions in Alaskan waters. Papers describing results from the Bering Sea MIZEX (Marginal for Some Experiment) are encouraged.

nourd by I. Amil 1984 to Smart Bigler, National Weather Service, 701 C. Street, P.D. Box 28, An-charage, Alayka 99513. Anthony will be notified of accepiance of papers in early blay.

University of South Alabania. Faculty Position. Tenure-track position at the tank of Assistant Professor in one of the two hullowing fields: (Il Inverteirate Paleoniology-Stratigraphy; (2) Igneous OR Metamurphic Petrology. The University of South Alabana has approximately 10,000 students, and is located in a growing metropolitant area. The Department of Geology and Geography has approximately 200 majors, and a faculty of nine full-line and three partitions mountain first position is about the control of the con ond three pari-time members. This position is not filled commenting September, 1984. The deadline for applications is May 15, 1984. Please submit leber of application, along with a resume of your education and experience, the Dr. Glenn R. Schaulan, Chairperson, Department in Geology and Geography, University of South Alabama, Mobile, Alabama of the South Alabama is an equal opportunity, affirmative action employer. three part-time members. This po

retures of New Mexico Pateoniagnetism. The arthurst of Geology of The University of New to invites applications for a termic track fulltime position as an Assistant Professor with a spe-nially in paleomagnetism beginning Fall 1984. The successful conditate will be expected to maintain an active research program and trach at the undergrad-tate and graduate level. The Department has six-teen full-time facility, is located in a spectacular nat-mal senting and has excellent analytical lacilities. Applicants should submit a resume, transcripts, and three letters of recommendation to R. Ewing, Department of Geology, Albuquerque, New Mexico 87131. The deadline for applications is April 10, 1984. litue passition as an Assistant Pro-The University of New Mexico it an equal oppor-

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Air Force Geophysics Laboratory Gsophysica Scholar Program [1984–1985]. The Air Force Geophysics Laboratory (AFGL) and The Southeastern Center for Electrical Engineering Education (SCEEF) automate that applications are invited for research appointments during the 1981–1985 rear in the Geophysics Scholar Program. This program provides research opportunities of 10 to 12 months duration for selected Engineers and Scientists to perform research in residence at the AFGL, Hanston AFB, near Boston, Massachusens, Scholart will count AFB, near Boston, Massachuseus, Schidart will be selected primarily from such fields as Geophys-ics, Annoydeere Physics, Mercorology, for Chemis-try, Applied Science, Mathematical Modeling using Communers and Engineering

computers, and Engineering.

To be eligible, candidates must have a Ph.D. or To be eligible, catididates intust have a Pla.D. or equivalent experience in an appropriae technical field. Some appointments may be confirmed prior to August 1984 so early applications are encouraged. All qualified applicants will teceire consideration without regard to race, color, religion, sys, or national origin. Application Deadline for September Appointments: August 1, 1984. For further information and application forms contact: SCEEE, 4101 Massarbuserts Avenue, St. Choud, FL 32760 Telephone; (305) 802-61-65.

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Faculty Position/Florids Atlantic University. The Physics Repartment is soliciting applications for an experimental physicia in a termic line position at the Astistant Professor level beginning August, 108.1

Candidates must have a Ph.D. degree and have demonstrated a commitment to research and teaching. Preference will be given to cambidates with

received with a great of raminates where, op-tics, or solid state phrtici.

Salary is negotiable. Deadling for applications— April 1, 1984 Lantaer Dr. Bjorn Landown, Clair-man, Department of Physics, Florida Allanti, Uni-versity, Bora Raton, FL 33 L31, Tel (305) 393-3481.

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Groundwater Hydrologist. Fulltime porition Ph.D. in Civil Engineering or Ceolydrology with one to five years expensive or M.S. with eight to ten years experience. Dattos will corost of developing groundwater quality research ideas, seek banding and complete hundred project Basic grodydrologic skills required with strong ymphasis on chemical has kground. Modeling skills destable, Applican most demonstrate road oral and written communic. of the Squarmat, Abduring skills of Statute, Applicant must demonstrate good of all and written communication skills, be interested in developing own ideas and in assisting in staff normagement. Send treatness for pairs P. Calbi, Head, Groundwater Section, Illimors and Water Survey, Box 3050, Station A., Uhampaign, H. 61820, 247-333-0236.

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is allable.

Send letter of application including basel description of research interest and goals, resume and names of three references to:

Son W. Levandouski, Department of Caroscietics, Pardine Priiversins, West Labavette, Indiana 47:07, Classing date for acceptance of application is Mart. 1984 or mult the position is filled.

Purible University is an equal equational valuematic axion employer. University of Rochester/Postdoctoral Position in Oniversity of Koonesserirosidoctoral Position in Low Temperature Geochemistry. The Hepati-ment of Geological Sciences has a positionout a posi-tion for research on low-level, naturally occurring tadioisotopes (Be-10, 7.1–36, 1-129, etc.). The re-Physicist. The Notional Overnic and Atmospheric Administration (NOAA) automates a fluridate. CS-13, vacancy in the Environmental Revers II administratives, Spare Environment Lationatory, Supporting Research Division, Boulder, Colorado, Starting salary at GS-13 by et is \$30,152. Tunirs include conduction of the property of the proper search involves the separation of trace automated these elements with emphasis on the measurement of 1-429 in a variety of materials to realizate its potential as a tracer for third movements. Measure-ments will be carried out on the University's tandem

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Geophysicist/Applied Mathematician, The University of Tulsa. The Impartments of Geosciences and Mathematics in sin application for an anticipated senior position with a joint appointment in both departments. A proven record of research and teaching in mathematical geophysics, ant/or mathematical physics is required. Experience in exploration geophysics that processing is desirable. The closing date is March 15, 1984. Send water and letters of reference to:

Edward House, Chairman Department of Geosciences Geophysicist/Applied Mathematician, The University of Tulsa. The Impartments of Geosciettes

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Faculty Position/University of South Alobama. The Department of Geology and Lieugraphy is seeking to fill a tenure-track position at the Assignant Professor level, beginning September, 1984. Applicants should have major training and experience in geological application of remote sensing, and rouge phase of economic geology. The Ph.D. degree is required This is a growing department with a present full-time faculty of the geologics and for geographers and approximately 200 majors. Please send resume and arrange for three letters of reference to be sent to: Dr. Glenn R. Sebastian, Chairberson, Benattment of Geography.

enter to be sen to: 111. Centur A. Scosstati, Chari-person, Pepartment of Geology and Geography. University of South Alabania, Mobile, A.L. 36688. Applications should be sent before May 15, 1984. The University of South Alabania is an equal op-portunity, allumative action employer. Physical Oceanography/Skidaway Institute of Oceanography. A physical oceanographer with a Ph.D. is being sought to readded research on the confluental shelf. Preference will be given candidates with expertise in the useful at the size of the confluent shelf.

continental slieff. Preference will be given candi-dates with expertise in theoretical physical occaning-raphy and who are interested in slidying and mod-elling ocean-ratharine exchange processes and/or continental shell circulation. Such studies will rom-plement and gnude experimental programs presen-ly being confinited at the Institute. The selected ap-plicant will be appointed at a level and salary con-mentagrate with experience.

Interested persons are encouraged to submit a resume, the names of three inclinionals who can be canacted for reference purposes and a concise satement of research interests to: Dr. Jackson 13. Blanco. 1912;150-2457, Skidawar Institute of manion, 1912/D30-2337, Skidawar Institute of Oceanography, P.O. Box 13087, Savanicali, GA 3144th before the deadline of March 30, 1984. The Skidaway Institute of Oceanography is an equal opportunity/affirmative action employer.

Glay Mineralogy/University of Illinois of Urbsna-Ghampaign. The Hepartment of Geology invites applicants for a tetrate-track landly position in clay mineralogy. We are seeking conditions who have clearly demonstrated the potential to be outstanding researchers in the general areas of mineralogy, ex-tailographs and chemory of clay minerals, in the origin, diagenesis, and metamorphism of argilla-cems sediments and fellow burne research will complement our existing programs in the petiology and diagenesis of sediments, experimental studies o compaction and of kinetics of furtial diagenesis, berougaction and of kinens of furfal diageness, re-havior of day innerals during deformation, perfo-lenting cology, and stable isotope groule mistry. In addition to the development of a strong research program, the successful and futures expected to participate in all aspects of teaching and advising a the graduate and under graduate levels.

The Herarment of Carology houses a variety of facilities for clay mineralogy research, inclinding s-ray diffraction and throrest ency units, an atomic ab-sorption spectrophotometer, two NMR spectrom-

supprincipe trophorometer, two NMR spectronsciers, an isotope-tatio mass spectrometer, and electron microprobes. Numerous other analytical services are available on campins, particularly at the Materials Research Laboratory where there is equipment for Auger electron spectrometer, years photoelectron spectrometry, scattering electron microscopy, mansureston electron microscopy, mansureston electron microscopy, and immoroprobe studies.

This powifor is available immediately. PhD is required. Rank and salary will be commensorate with experience and qualifications. For equal consideration, please submit a letter of application that includes a statement of corrent and lumper research interests as well as a curriculum viace, bibliography and the names of at least 3 references willing to comment on rour qualifications and promise by April 1, 1984 in Dr. Albert V. Carozzi, Chairman, Search Committee, Department of Geology, 245 Namral History Building, 1301 W. Green Street, Urbana, R., 61901. Phone: 217/333-3008.

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Marina Geology and Geophyalca/Univaralty of Washington. The School of Oceanography is seeking candidates for a position as Research Assistant Professor, but applications at a more sentor level will be considered. Preference will be given to a candidate who has research interests in marins geology and geophysics and who will interact with our ongoing research projects, especially in the area of ridge-crest processes. Although this position will eventually be funded through self-generated research grants, partial financial support is available for the first two years. Teaching requirements will be limited and at the graduate level. For consideration, send a cestone, a brief letter describing research interests, and four letters of reference by 1 May 1984 to:

search interests and May 1984 to:
Professor Brian T.R. Lewis Director

School of Oceanography, 198-10

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Postdoctoral Position/Atmospheric Chemistry. A postdoctoral position is available for a person with a Ph.D. degree in themistry (preferrably analytical or physical) or interometeurology. The position involves the measurement of annospheric scidity and the dry deposition of trace gases from towers and aircraft. The enecessful applicant will be expected to travel in a variety of field sites and to perform chemical analyses using ion chromatography, A facility with computer programming, the labrication of research equipment, and careful chemical contamination-control would all be useful.

This is a two-year full-time position, with an annual belary of \$15,000 during the first rear, to begin in the summer of 1984. Interested persons should send a resume, names and phone numbers of three references, a statement of research interests of three references, a statement of research interests, and any reprints to Barri Thuckert, Department of Chemistry, Colorado Springs, C.11 8000.

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STUDENT OPPORTUNITIES

Opportunity for Graduate Study in igneous Petrology/Isotope Geocliemistry—Southern Methodist University. The Department of Geological Sciences at Southern Methodist Provents in Italias, Texas seeks outstanding individuals interested in a Phili program in igneous parriology and/or portogram in igneous parriology and/or portograges chemistry. The successful applicant should have a strong background in goology, chemistry, and notativements and an interest in voltanic processes. Research will involve participation in a field-oriented periological, geochemical, and isotopic study of late Canazoic volcanism in the United Articles. For further details and analysis these contact culture ther details and applications please contact either. Dr. R. S. Harmon (244) 692-5075

> Dr. M. A. Dungan (214) 692-2752 Bepartment of Geological Sciences Southern Methodisi University Dallas, Texas 75275

Stote University of New York at Boffalo/Assistant-ahip Opportunities. The Department of Geologi-od Sciences invites graduate applicants for full 1984. Graduate-Leaching assistantiships offer a su-pend up to \$55,00 00 for 10 months, plus tunion water. Special assistantiships in grophysics, geochemistry-mineralogy, and glaciologs carrying a 10-month stipent of \$72,00,00 plus mitton waiver are available. Arldnional summer support is possi-ble Applications can be obtained from the flepara-ment of Geological Sciences, 4240 Ridge Lea. Am-teria, NY 14226, 716-831-3051. Dearline for re-ceipt of all materials is March 30, 1984. The State University of New York at Buffalo is an allignative action/equal opportunity employer and

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# AGU Congressional Selection Science Fellow: Midterm Report

Research Associate. The Unoperative Institute for Research in Environmental Sciences (URES), University of Cadorado, Boulder, Colonado is adver

Unifference of Substances from the position. The posi-tion description is as follows. For introductic will initially participate as a mendary of a team of scien-tists in CTRYS and NOAA mostred in the develop-

initially pairicipate as a menthry of a team of scientists in C1RFS and NOAA mostered in the development and calibration of two IVV spectros about restor for na ket-dight torsourcinents of the solar IVV spectral irradiance. This treated is part of a program to determine the temporal variations of solar IVV radiation, then stratospheric effects and possible effects on climate. The incumbent will participate in mountain-top measurements with the long-wavelength UV spectroradiometer to obtain direct intercomparisons at IVV wavelengths with the mountain-up solar spectral irradiance measurements in the near UV, visible and intract in rollaboration with the Unitersity of Arizota. The incumbent will be responsible for the integration of the UV spectroradiometers into a rocket payload including developing the electronic integration of the respective of the incombent, the integrating member of a team to being in charge of the follow-on rocket experiments, including the lanath-site expertitions, readilinations, and reignating proposals to government agencies for rocket-dight and ground-stations support.

The expeditions and desirable experiments and propriate and programments and desirable expertitions.

posals to government agencies for rocket-flight and ground-stations soul desirable experience are as follows: a research scientus with a Ph.D. degree or equivalent in either physics, autooptheric science, avirolphysics, meteorology, electrical or mechanical engineering with two years of research experience is required. Design and testing experience with electronics systems and microprocessors but use in the harsh environment of space, and for surviving the high-eibration environment of lanuch are required. Experience in racinom UV space, and for surviving the high-eibration environment of lanuch are required. Experience in racinom UV space, and for surviving the high-eibration environment of lanuch are testing to accept the experiments of sit stoopheric research would be highly desirable. The salary range it \$23,000-\$50,000 depending on experience.

To apply for the position, applicants should submit a letter and complete resume including publications. In addition the applicant should request let-

mit a letter and complete resume including publica-tions. In addition the applicant should request let-ters of recommendation from three individuals fa-miliar with the applicant's personal and professional qualifications for the position. All application mate-nial should be forwarded to: Dr. Robert F. Sievers, Director, CIRES, Campus Box 449, University of Colorado, Botthier, Colorado 20209. The closing date for suedications is April 15, 1984.

date for applications is April 15, 1984.

The University of Cadorada is an affirmative ac-

Assistant Professor of Geophysles/Purdue University. The Repartment of Decstriencer, Purdue University antiquetes an opening for a new tenure track position at the assistant professor feed in the area of exploration geophysics. The successful applicant must be prepared to assist in teaching exploration geophysics courses, advanced topics in his/her specially and tlemonest are an additional or industrial experience is desirable. Postdortotal or industrial experience is desirable. The grouphysics program in the Repartment of Geosciences at Purdue University entremit consists of four full-time geophysics faculty. Field and Laborators equipment and laddities are available. For application to seismologi-

partities are available for application to seigmodell and fashibles are available for application to seismologi-cal and potential held geophysical methods. Excel-lent computing lacilities including a 1-year 205 com-puter operated for Purchie University and main-com-puters within the Department of Taxos terters are a cilcle.

during research on the phraics of the solar corona as related to the emission of master and radiation which result in disturbances in the mear-cault envi-

physical research is required. For lander information, Demonstrated achievement in fosic astro-physical research is required. For lander informa-tion and application procedures, please call Mury Plumler, NOAA Personnel at (303) 407-3102. Ap-plications must be received by March 30, 1984, to be considered.

Jack Fellows

As the recipiem of the 1983-1984 AGU Congressional Science Fellowship [Eas, September 6, 1983, p. 543] I have been asked to report on my midterm experiences. I have learned twn major aspects of business on Capitol Hill. First, I am impressed by the tre-mendously important relationship between science and the political world of Congress. Congressmen need and actively seek technical advice on legislative issues. As a scientist, one's point of view can have an impact on so

ciety as well as on one's discipline. Second, I have been overwhelmed by the dedication of members of Congress and their staff. As in corporations and academia, the politics and bureaucracy can suffocate in any good idea. However, considering these things, plus overlapping committee jurisdic-tions and the inherently difficult legislative process, it is still a wonderment to me that

Congress manages to produce anything.
The AGU Congressional Science Fellowship consists of four phases: selection, could tation, placement, and assignment. I would like to discuss each one of these phases: through each, I feel that I have learned and grown both personally and professionally:

Application required a letter of intent, vita, and letters of reference. Once short-listed, one wrote and presented a congressional briefing to a peer review board. I chose deepseabed nathing as my topic; it offered me the opportunity to show my ability to research a briefing on (to me) a totally foreign topic.

#### Orientation

In addition to AGU, 19 professional societies enroll their Fellows in the AAAS Congression sional Orientation Program. These societies include the AGU, ACS, APhA, NSPE, 1EEE, and others. This year there were 42 Fellows, ranging in age from 28 to 50. All but 10 of the Fellows bave their doctorate.

Fellows have been placed in Congress. OTA, and the State Department. Besides constantly tapping our Fellows network (the Fellowship) for legislation information, we have regular dinner and lunchenn sentinars and informal meetings. We set up our own seminars, which have so far included topics like Central America, ethics, the "gender gap," arms control, risk assessment, and lobbying. I have had the great pleasure of being the chairman of this year's Fellowship.

The goal of orientation is to prepare one for placement in the personal office of a number, on a committee staff; or in some other congressional branch. This program is a rather grueling sequence of congressional briefings from congressional agencies, members of Congress, committee staffs, historians,

others. In addition, there are meals and receptions with speakers, members of Congress and congressional staff. The Fellows' friendship develops through this exhausting hut thoroughly enjoyable "bont camp." The AAAS orientalinn is similar to the orientation that freshman congressmen undergo. By the end of the 2-week period, one has a better understanding of how Congress is structured, nate Iron Congress and shape Congress. The contact with enngressmen and staff makes one aware of the important "players" in Congress. Now was the time for placement.

AAAS representatives, former Fellows, and

Interviews We were now let lonse on Capitol Hill to find a position for a year. All the interesting aspects of congressional work we had heard about during the mientation made it very difficult to chose the appropriate member, committee, subcommittee, or engressional branch, Prior to the orientation, I had chosen to work on hydrologically related Issues. However, during orientation I had arided to my list the areas of innovation, productivity, industrial policy, high-tech tlevelopment, and

foreign affairs AAAS provided its with a room full of phones in the Sennte Hart Office Bullding, a list of congressmen looking for Fellows, and interview commens from last year's Fellows. The AAAS leadership and support are indispensable to the success of this program. I left my condensed, one-page resume at

both the Senate and Hnuse sides. I went back to many of these offices two or three times. There was a constant exchange of interview information through the Fellowship network and relatively little enumeration. We found out a lot about ourselves. Congress, legislative issues, and especially the underground tunnels interconnecting the congressional office In spite of all my criteria for choosing an

office in which to work, my choice rested very heavily upon office "clsemistry." I chose to work in the personal affice of Rep. George E. Brown, Jr. [D-Gal.).

#### Work

Besides being on the House Science and Technology Committee and the Hnuse Agri-'cultural Committee, Rep. Brown has a personal interest in remote-sensing applications, water resources, and data base management, all of which I was involved in at the University of Maryland. Some of the other Fellows have told me that the members they work for do not even know their Fellow's name. I feli: 'quite forminate in this respect, because I get a chance to talk with Ren. Brown frequently and I have accompanied him on hearings and speech trips.

For the first 2 months, 1 read congressional reports, attended meetings, hearings, used floor debates and familiarized myself with

AQU [cont. on p. 78)

#### AGU Congressional Science Fellowship

The Individual selected will spend a year on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science and be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a supend of up to \$28,000, plus travel

Interested candidates should submit a letter of intent, a curriculum vitae, and three letters of recommendation to AGU. For further details write Member Programs Division, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009 or telephone 462-6903 or 800-424-2488 outside the Washington, D.C., area.

Deadline: March 31, 1984

AGU (cont. from p.77)

congressional and office procedures. I was given industrial policy, space, information and water resources policy as issue areat. I was not given a specific project, except a speech on the role of the federal governmen a science and technology. During this time I helped on affice projects and constituent work. (The volume of letters, requests, and information coming in to a congressional uflice is staggering.) I attended Congressional Research Service programs to familiarize mysell with the Library of Congress and its clara-

In November, Rep. Brown asked me to examine the possibility of drafting legislation for the commercialization of Landsat based on discipline resolutions and not the 80-m resolution of current proposals. I learned a great deal about possible suggestions at the National Telecommunications Conference

and Jet Propulsion Laboratory. However, after Congress adjourned in late Naveniber, I was asked to write four speeches on industrial policy, innovation, R&D, and productivity tupics. The Landat proposal was shelver! for a while.

During the receis Rep. Brown also asked me in examine an Office of Technology Assessment recommendation that the United States needed a Nutional Center for Water Resources Research modeled after the successful National Center for Amospheric Re-search. I have made some proposals for such a structure that have generated interest with Rep. Brown, members at the Interior Commince, and the National Association of State Universities and Land Grant Colleges. The

Pasquale Lanciano [T], Timothy F. Lawton (T), James Leaird (S], Craig Lindberg (S], K. timing may actually be currect for this legislation. A lot of politics and arrangements must K. Lin (A), Mitchell W. Lyle (O), Peter Lysne be worked out before such a bill will be introdural. However, this legislation has now be-

Ann Macsi (V), Maureen Mahoney (V), Marangu Marete (H), Claire Max (SS), Linda

anyone regardless of profession or age.

**AGU Membership** 

Applications for membership have been re-ceived from the following individuals. The

Raffi Aroian (P), David Baker (P), D. Graig

Bariloni (O), Stephen J. Barnes (V), Thomas O. Barnwell (H), Robert P. Beneute (G), Bri-

an Bicknell (H), William Blumberg (A), Mi-

chele A. Boccadoro (G], Richard Buylan (T), Robert C. Bucknam (T), Roman J. Budzian-

owski (H), Bruce M. Crowe (V), Charles G.

Calvin R. Dunlap (O), David M. Farmer (Ol, Terry Fundak (G), Oswaklu Garcia (Al,

Moises Garcia-Milnoz (SC), Oktaj Guven (11),

Paul P. Hearn (H), K. V. Hodges (T), Kerry

Richard Janda (H), Kathleen M, Johnson

(V), Alan G. Jones (GP), Thierry Juteau (V), Peter Kearl (H), Tee Keith (V), W. J. Keith

(V), Len Kobus (S), Randolph A. Koski (V),

Edward Laine (O), Kenneth K. Lajoie (T).

F. luman (T), Tom lutrator (SS).

Donathon Krier.

letter after the name denotes the proposed

**Applications** 

primary section affiliation.

McAdamy (S), Anne McCormack (Ib. that it will make it to hearings believe I have. Homas P. Milba (V), M. Daniel Mortism

but I am endeavoring to lay the formulation I am enjoying the Hill very much. I know Richard K. Nishimori (V), Tarsuki Ogino already it has had a great impact out my life. I (SML Govanni Orse (V), Sickano Orsin (SML know I will remain politically artive when I George A. Parks (11), Paul R. Passinore (St. J. retorn to the scientific community, and I P. Parel (GP), Jose M. Perez-Godov (II), would highly recommend this program to

James Robert Podolske (Ac Benjamin L Rice (1), James M. Roberts (A), David A. Segmann (O), Les E. Shephard (O), Andrew W. B. Siddans (1), Juel A. Silter (A), Siephen P. Smith (V), Claude Lames Steeling, R. N. Su-

Havid J. Terrell (V), Robert H. Thomas (II), Vees M. Tourre (O), Midwel Trainer (A), Taku Urabe (S), Juse Frii Valdes-Galicia (SCI, Kunimiko Watanabe (SM), Lawrence Weiss [11].

Student Status

Inn Abravano (V), Dave Boden (V), IL Herbert Bremeinan (SCL Mary F. Caress IV). Stefano Casotto (G), J. Vintent Eccles (A), Bruce Finney (O), Peter H. Gleick (A), Ann Isley (O), Sungtack Kwon (V), late Moxon, Kim Marphy (O), David W. Minray (O), Nell B. Myers (A).

Brian B. Quinn (S), Ingrid Reuber (I), Joseph Shields (SS), Carl L. Sielring (SA), Deborali K. Smith (1), Mary Streeter (8), Mohamed Sultan, Akiko Urabe (VI, Ludovit Varga (SM), Jay D. Winisley (A).

#### AGU **MEMBERS**

Please write your member identification number on your check or money order to speed accurate processing by AGU.

# Meetings

## Announcements

## **Elevation Datums**

Elevation damma are the subject of a 1-day program on March 13, 1981, at the annual meeting of the American Congress on Surveying and Mapping (ACSM) and the American Society of Photogrammeny in Washington, D. F. Jointly quansured by AGSM, the American Association for Geodetic Surveying, and AGU's Geodesy Section, the session will leature 11 papers. Registration for the session at member rates will apply to AGU members. For further information, comact Thomas J. Lamterborn, Rte. I, Box 127, Waterioni, VA 22190, telephone 703-882-3834.

The paper titles and authors for the program are as follows:

Himorical Overview of Vertical Datums, Herbest W. Storeghton Genmetrical Aspects of Vertical Datmos, J. II.

Boal, F. W. Foung, and R. Mazasche Defining Vertical Datums: What Is Zero?, Aspects of a New Height System for North America, Sandford R. Holdald

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Fennos andia Upliti, Plate Tectonics, and Seismicity, and Their Elicus on Vertical Datums, Larry Brown

Delmition: Oceanographic Approach, Bruce C. Dauglar and Robert E. Chaney The Determination of Genderic Height From Laser Tracking Data, Duvid E. Smith and Demos G. Chardodoulidis

Deep Sea Techniques and Venical Datums, William E. Carter

Gravimetric Approach in Delining Vertical Datums, Luman E. H'ilcox NAVD 1988: A Status Repnri, Charles T.

The Administrative, Political, and Economic Aspects to He Considered in the New Definition of the Vertical Datton, John D. Bossler

# Geophysical Year

#### New Listings

June 11-12, 1984 Fifth European Conference on Environmental Pollution, Amsterdam. (V. M. Bharnager, Box 1779, Cornwall. Omario K6H 5V7.)

July 5-6, 1984 Second Symposium on Plan ma Double Layers and Related Topics, nsbruck, Austria. (R. Schrittwieser, Just. for Theoretical Physics, University of Innsbruck, Sillgasse 8, A-6020 lunsbruck, Austria. (The deadline for registering is May

September 20-21, 1984 International Symposium on Environmental Pollucion, Site To Be Announced. (V. M. Bhatnager, Box 1779, Cornwall, Ontario K6H 5V7.)

September 24-26, 1984 International Waler Well Exposition, Las Vegas, Nevada. Sponsor, National Water Well Association (National Water Well Association, 500 W. Wilson Bridge Rd., Worthington, OH 43085; icl.: 614-846-9355.]

October 10-12, 1984 Seismologiesi Society of America Eastern Section 56th Annual Meeting, St. Louis, Mo. (Robert B. Herrmann, Department of Earth and Atmospheric Sciences, St. Louis University, P.O. Box 8099, St. Louis, MO 63156; tel.:314-658-3120.)(Abstract deadline la September

November 1984 Mexican Geophysical Union Annual Meeting, La Paz, Baja California Sur, Alexico. (Uniun Genlisien Mexicana, A.C., Comire Organizador Remien 1984, Aparrado Fostal 1805, Ensenada 228001. B.C.N. Mexico.)(Abstract deadline ls August 1.)

April 9-11, 1985 Fifth Annual Front Range Branch Hydrology Days, Fort Collins, Colo. (11, J. Morel-Seytons, Hept. of Civil Engineering, Cala. St. Univ., Fort Collins, CO 80523; (el.: 303-491-5448 or 8549.) June 201-28, 1985 U.S. Symposium on Rock

Mechanics, Rapid City, S. H. Spauson, South Dakota School of Mines and Techmology. (Eilern Ashwurth, Chairman, 26th U.S. Symmosium on Rock Mechanics, Department of Mining Engineering, South Dakota School of Mines and Technology, Rapid City, SH 57701-3995; rel.: 605-394-2344.5

August 19-30, 1085 23rd General Assembly of IASPEI, Takva, Japan. (Ryosake Sato, Secretary-General of the 23rd Gener al Assembly of TASPEL, the Inter Group Corp., Akasaka Yamakatsu Bldg., 8-5-52. Akasaka, Minant-ku, Tokyo 107, Japan: tel.: Tukyo (03) 479-5311.1

The Geophysical Year calendar last appeared in the December 6, 1983, issue.

## Separates

To Order: The order mamber can be found at the end of each abstract; use all digits when ordering. Only papers with order numbers are available from AGU, Cost: \$3,500 for the first article and \$100 ho each additional acticle in the same order. Payment must arrompany order. De-

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#### Geochemistry

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## Geodesy and Gravity

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#### Geomagnetism and Paleomagnetism

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BEHAVIOUR OF FIRE MAGNETIC FARILCLES IN ROCKS

J. B. Boyd, H. Fullar (Department of Geological
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California 93106] and S. Helgedohl

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who under a side range of term and perturbed conditions.

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1720 Climatology EXPECTS OF BYNAMICEL HEAT PLUEFS ON MODEL CLIMATE SEMELTIVITY ENTERTS OF BYMANICEL MEAT PLINES ON MODER CLIMATE EMPLIFYET W.-C. Mang (Lineaphritz and Snvi noments Research, Sc., Cashridge, M. 02139), O. Moinar and T. P. Mitchell, and f. H. Sione (Canini for Meleorology and Physical Genengraphy, MIT. Carbridge, M. 01135) The afface of the settletone and varietal dynamical hast fluxas on climase mensitivity is lovestigated using an annual mean coupled high and boy latitude radictive-dynamical model of the Marthers Remimphere. The model was consequented by Receptoratins a satisface has reliable lateophere and ocean) dynamical heat thus garameterization into a row-room flow lettude O-DOW and high lufflude 30-90W working of the wartical tadictive-towerstwa model. The atmosphere vertical dynamical heat flux is persecuted as destroyer to covere live Adjustment with two trivical lapse rates - the model selected lapse see and the crivical velve for herotlinic adjustment. The settletonal dynamical heat flux is inlessed to the meridianal resperature gradient continuity. Cloud covers and stitudes and relative

inclused. The dynamical bast fluxes is found to profuce a strang stabilising effect on tilines. The writing of the bestporter mean surface importance induced by a 21 increase in solar constant and a double. Induced by a 21 increase in solar constant and a dou-bling of carbon disside concentration could be increased by as much as a lactor of a 1f the leedbaths from the meridional and wartical dynamical heat fluxes was both eliminated. The coupling affect of the ser-tical and meridional heat fluxes is also caltulesed to be very strong, i.e., the vertical flux feedback is strongly stabilizing in the presents of meridional flux feedback, but dearabilizing in the samence. In fact, the model's current climin is unstably in the latter see.

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## Oceanography

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Journal of Geophysical Research

Volume 89 Number A3 Merch 1, 1984

New Empirical Models of the Electron Temperature and Density in the Venus Ionosphere With Application to Transferminator Plane (Pages 3A)8421 Three-Dimensional Ray Tracing of the Javian Magnetosphere in the Low-Frequency Rango Paper 3 A 1905;

Aperiodic for Temperature Variations in the la Plasma Torus (Poper 3 A 1836)

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F. M. Iparich, J. T. Ovrling, and M. S. holer Megnetopause Structure and the Question of Particle Accessibility (Paper 3A1921)

The 40-keV Electron Ourable Trapping Region Paper 3A16271

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J. Fernman, D. A. Hards, and E. G. Mollon The Radial Distribution of Radiation Bell Frotons: Approximate Solution of the Steady State Transport Equation of Arbitrary Pitch Angle 1Paper 3A 17081

The Clobal Distribution of Thermospheric Odd Nitrogen for Solution Conditions During Solur Cycle

R. G. Roble and J. F. Kaiting

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J. D. Winingfulm, J. L.

kinetic curry decreases west- and contrare and le contentrated along the South Atlantic Current. It appears that the North Milantic Current (Polar Prop) i is the take name of only blocks groups for the northern Borth Atlantac, whereas the Blockel and to hidge is no source of easy energy. Buty tiretic charge thought be borth intentio Correct decreases. trum about 1969 car s<sup>-2</sup> near lies. Fo artlant to 300 -a/. and meet of Contland, Albandeno is post of less eduy. Finally energy fluxs than 100 cm s  $^{-2}$  tagear in the control Forth Atlantic rest of the Mid-Arlantic Eddge. The level increases (examp the Empopour and African) shelf where the mean acutioned flow also becomes sir now. The results exceen the upper ocean, this Namble, Brown electrication, delfting Lucyse. J. Coophys. Soc., C.Poper 400154

4761 Burface waves, 11des and see level APPLICATION OF A BIMPLE NUMBERICAL WEEE PREDICTION HODEL TO LAYE SELE

David J. Behwab (Great Lakes Environmental Research Laboratory, KOAA, 2300 Vashrenav Ave., Arm Arbor, Mi. 481041, John H. Denmett, Paul C. Clu, and Matk A. Denmeten

A parametric dynamical wave prediction model has been sdepied and tooled against smalametric empirical results for steady conditions in a circular hasin and extensive liel measurements of wave height, pariod, and direction. The ndapted numerical model Securetally predicts the directional systemating of waves for unitors assed wind prodicted easily icelly for letchindised waves. When the model was applied to the contral basin oil lake Erie and she results compared to observations of wave height and parind for two points in the lebel and direction (at one point), results for wave height and parind for two points in the lebel and direction astimates were smellen compared to measurements at a research rowt of the southern shorts, but computed wave heights were lower than observed as a weather boy 10 the western part. The model semantal underestiment wave pariods at both places. Thus, with locally measured wind dais as input, the model settiment wave height and direction J. Geophys. Res., L. Paper 450201

#### Particles and Fields-Interplanetary Space

Sillo Cormic Raya (Solar Modulation)
Solar Modulation of Cosmic Ray Electrons (978-198)
Paul Evanson Hariol Bassarch Foundation, University
of Palawore, Newart, DE 19111, and Poter Heyer.
The 1989-1 apaceraft has provided over low years
of continuous data (from herby University of Palawore, Newart, DE 19111, and Poter Heyer.
By using these data together with pra-launch calibration data and practas electron spectra from balloon
filights in 1979 and 1882 at Thompson, Mantroba, Canada
we monitro: the flux level of approximately i DEV conmit ray sincirons with one wonth line resolution.
The singlise osset of medulation observed (or positive
particles in 1979 is also seen in electrons continuting these the deciment sodulation machenism is not
unnative to the charge of the positicle, Heystratis
elfacts observed in the previous solar mentarm by
Burger and Swamenburg (1977) ats not reproduced at
the present octar maximum, A ratum to the relativity
figher electron/pricon lating of the 1987's is a
scrong possibility. Conclusions must be drawn with
caution, however, since the overall if no structure
of the prevent solar mentarum is selected, and
electrons, solar modulation, gradient and culvature

#### Particles and Fields— Ionosphere

3320 Electric ligids
AN EMPROT PRINCIPLE FOR MICH-LATITUDE ELECTRODYNAMICS
D.D. Barboss (inmittude of Geophysics and Flanctary
Physics, Utla, Los Angeles, CA 90022)
A Theoratical codel for side and bigh-islitude significant light and currents (a committed using fourier energysh mathods. A two-diomational planar Lunosphere with me ombanied conductivity surers) belt sed itself-nighted currents at the edges (a Leployed. The position to the committee that he cincip itself-significant committee adjust Self-conficiently in biblists the global Joule disalpation rote defines a theoretical relation between the primary and secondary field-slighed currents. This second in the secondary is a secondary included in the secondary in the committee of the secondary dependence of the secondary models and scophical solutions for the electric field and lonosphoric current are shown. A detailed discussion and

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1715 firstric fields
RELATIONERIP OF DUST BECTOS RADIOL EXECTOIC PIELD TO
EMPROT DISIGNION AT THE LUNCE EDGS OF THE SIPCTRON
FLASHA SHET?
d. L. Horvitz Physics Department, The University of
Alabama in Sunivville, University, Alabama 188591
it is shown that, semuming tendicious of
approalment steady state and that the low-to-madelum
electrons loreing the please sheet lears edgs
originals from a mource in the magnetotalt, the
yedial electric lield in the dusk sector can be
related to the redail energy dispersion of the pleasa
sheet linear boundary as

The Radial Distribution of Radiation Self Proteon: Approximate Solution of the Steady Steic Transport Equation of Arbitrary Pitch Angle Lingor 3A (1781) [152]

Streaming Reversal of Energetic Particles in the Magnetotal During a Substorm I Paper 3A [372]

The Structure of the Flarme Sheet-Love Boundary in the Earth's Magnetotal (Paper JA1489) [153]

Bestiren Derity and Plasmapause Characteristics of Scale (1884) [154]

Bestiren Derity and Plasmapause Characteristics of Scale (1884) [155]

On the Relationship Between Morolog Sector Irregular Magnetot Stephyl, M. Crambia, V. F. Fernance, V. B. Bestiren, J. A. Forder, V. R. Fernance, V. B. Pernance, and V. Lemantron

On the Relationship Between Morolog Sector Irregular Magnetot Stephyl, R. V. Schuth, and S. J. Resembra;

Global Ionophrisms, L. J. Collil, R., T. A. Puemra, L. J. Zanstif, R. L. Armidy, S. B. Mandr, ond T. J. Rossebra;

Global Ionophrisms, L. J. Collil, R., T. A. Puemra, L. J. Zanstif, R. L. Armidy, S. B. Mandr, ond T. J. Rossebra;

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Global Ionophrisms, L. J. Collil, R. T. A. Puemra, L. J. Zanstif, R. L. Armidy, S. B. Mandr, ond T. R. Rossebra;

Glo

interpretation of the solutions with toletion so di-verse observations and high-lacitude phenomology are included. (Electric fields, electric corrents, iono-J. Geophys. N. g., A. Papar 480245

J. Goophys. No., A, Paper 430245

Sin Righ Latitude Lonospheric surrents
OPTICAL KAPPING OF INNORPHERIC CONNECTIVITIES

S. B. Nende (Locinod Salo Sito Renearth Laborators,
325) Nanover Street, Pato tito, California 94704; N. R.
Sather, R. B. Rees, P. S. Wondrab, and S. V. Poblisson
Lonospheric Hall and rederson conductances are derived
from surrent apertroncopic neasurineans obtained with
saidlan seaming photosetsys. Conductances are also
derived from height profiles of electron density
obtained with the incoherent scatter rader at Chataniha
in a coordinated experient aimed at comparing the two
techniques. While general agreement is obtained by
using those basically different cephods, the
diesgreement illustrate the advantages and literations
of each experimental technique. The radar yields
Accurate values of conductance with limited temporal and
special resolution while the optical measurements
provide less accurate values at high time resolution and
over large regions of space. Homosphoric currents,
aurotas, efectric lields, particle greefplications.
d. Ocophys. Ses., A, Paper 341274 d. Ocephys. Bes., A, Paper 3AI B74

B530 Bigh-latitude ionospheric currents (SER-1 AND -2 OBSENVETIONS OF AN OSCILLATION OUTUARS MOSTING TURNEST SHEET HEAR HIDRIGHT.

J. Bully introdupheric Eciances Department, University of California, Los angoles, California, 900241, C. T. Pussoli and B. J. Maiker.
An outward moving current sheet is examined with the ISEE-1 and -2 magnetogaless. It is found that the current sheet is moving outwards with a velocity of about 17 Majasc, a thickness of about 1900 km, and with the current Howing into the lonosphere. Oscillations observed in the magnetic field profits indicate the presence of a wave traveling along the current sheet from uldnight lowered the mass with a velocity of 400 km/sec. The oscillations of the plasma normal to the current sheet same lated and with a velocity of 400 km/sec. The oscillations of the plasma normal to the current sheet same lated and this way are sufficient to explain the small current sheet observed by the UCB electric (Leid detector. In addition a strong later than the UCB electric (Leid detector. In addition a strong later than the second and the place of the current sheet observed by the UCB electric (Leid detector. In addition a strong lations to the plane of the current sheat observed by the UCS electric (leid detector, and distion a strong stactric field to theory of normal to the sheet, sorter-spending to a flow along the sheat of 400 in/eec, which is consistent with the volucity of the wave deducind from the interestellits riming of the oscillations. The the wave is stationary in the frame of the current sheat planes, this oscillating current sheat model explains the charred behavior of both the magnetic and attentic field observations. The potential drap across the current sheat was very large at this rise, 41-24 kt, and is comparable to the joint merost potential drap across the polor cap. If leid-aligned correct, electrostall, sheet, electric field, sivettir potential dropt, J. Osephys. Ros., A. Paper 440113

5180 wave Propagation HUNCRICAE SYMULATIONS OF INTENSITY SCINTICLATION USING THE POWER LAW PHASE SERVER HOOGE Ch. Pipe Pailo Physics Laboratory, 581 International 113 Racepascod Avenue, Benje Fark, Ca 94025), 1, Owen Simulations of regio-wave approlitation in power-law Simulations of redin-wave arginitiation in power-law modes were performed to study the attracture of the intensity and phase spectra when the Presnet radius is guth smaller than the autar acaim of the low-fraquency limit of the power-law isgine in the in-situ irregularity spectrus. The results werify the militual dependence of intensity scintiliation on the power-law index as predicted by both asymptotic and more returned theoretical computations. Because of more recent (indings, the acquisitation threaterstains of propagation in modia characteriaed by a ino-component power law ware also investigated. The results is cancille the interpretation of scintiliation data from the United and antility which showed a shallow aloped power-law phase spectrum with more second intensity scintiliation. Red. Left. Empit 489231

3199 General (Equatorial Spirad f)
RATILIGN-FATLOS INSTABILITY IN THE EPFSCHOOL A
STRATIFIFO SHEAR LATES TRATIFIFO SHEAK LATES P. Saspemerayana (Stionce Applications, Inc., McLann, Kisinia 221021, P.W. Gusdar, J.D. Huba and S.L.

Yishin 271021, F.M. Gudder, J.D. Numb and Sti. Omaskey
A noniced theory of the Payloigh-Tajlor instability which includes the effect of a transcripe volocity shoot is presented. A two fluid model is used in destribe as inhomogeneous plasma under the influence of gravity and sheared equilibrium liev velocity, and to desire a differential equation describing the genoration and application of the present of the present the study is tadd in the collisionices and tellistonic regimes, and the corresponding disporation turves are presented. The results are emplied to the equatorial fragion and to batton release in the londesphere. (Gravity, shear, Spread Vi. J. Reophya, Res., A, Paper 440228

## Particles and Fields-Magnetosphere

where (W, 1 represents the energy of the electron laser booksey. An increasing electric field temponent with radial distance Se objected from recent desturcionics of places about lower edge

WAVE MODIAL DIRECTIONS OF CHORMS MEAR THE EQUATORIAL SOURCE REGION

5. E. Coldstade (jes Propulation Laboratory, California Institute of Technology, Fesadene, California, 91(05), and B. T. Tauquteni

Wave propagation directions of post-addutable chorus in the oser-aquatorial segion in 1, shalls of 5 to 7 bave best determined from OCC-8 triasis! asseth coil base here determined from OGG-1 triaded assembled angustopeder data. Sampled melbods were used to set mants the wave natural directions; minimum striames, lengtary part of cross-spectral matrix, nightweeds of Harmilian cross-spectral matrix, nightweeds of Harmilian cross-spectral matrix, and fit of dispersion relations for one-wase and two-wave models to trois-spectral matrix. Comparisons of the schools and results are discussed in dainly. Wave propagation at all irecessness with observations of court to

and results are discussed in distil. Were propagation at all irequesties within charms tones was found to occup most frequestiy slogs the segments field with mediam and arrangs some angular of 9,10 and 12.20, respectively. All methods of sestyain gave sheller teaches. It is toucluded that the wave growth is sestimen for seven propagating parallel to 5. Our require me accessment with sales on in a merror base, but not as a broad angular distribution. The iron wave propagation model typically compiled to magnification in the could be improvemented to the residual buyond that obtained by season to that out only one wave was propagation and properties and at the residual hypord that obtained by senseing that only one was present an only if we came that any one was present. In only if we came that any one was present and that she it was a series at the residual hypord that obtained by senseing that only one was present securit. These enems earn names of selling to a emission werk present end of that she it is sense that she it is some that of the terminal of the terminal that it is most came and for the terminal that it is most the type-was node; given middledfing indication of mayer with large enemy flatter properting at very chilque angles east the teason does coom. This is intrinsed the wave group selectly goes to zero men the infinite organ and if she carts the did that are not none, there is seell amount of negmetic notes in something with a large wave margy flux. Some champine have, hann louid of a lower frequency have propagalish almost effectly along the magnetic field followed by a higher frequency burst transling a large angles to the magnetic field. These painting during a large to the magnetic field. These painting in meadode hetween policy of burst franciscon is requestively along the major of he put at meadode hetween policy of burst franciscon in the physical lamilestone era exceptions of the form of the physical lamilestone era exceptions, increase, wave normaln, these (specialities, interest francing the food.)

1. Geophys Lee., A. Apper 40.04)

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local pecaugnetic hield times. ISCI I and 2 observed the opposite takes of polarizotics for shart. In this stable, the executable were appeared by only 9 als in their orbit; this recarriable instance cannot be orbitally defined by other a stable take; a stable tending the control of their stable tending the stable tending the control of the control he estation by either a bid letter; \$130.00 to 12 a legis | Empired boundar | but could result from a lapid covered of the research region. We stiple that the cost likely essify squire in bounts resemble with cading energy to 1 ke?) tone. Calculations of the wave Poynting vicini at 1516 | suppose this conclusion.

J. Occuphys. Rom., Paper 640246

Plant have Propagation options of the control of th

The event was observed at the LL-I sarellite mear the equator in both electric and magnetic field corponents and it the ground respect to be executed. Alliantics, and Suberval (Quebec, 15 to he hast of Oktion and at other and at opposition and of an 1 - 4-2 field line. The 180 a and 240 s pulsations were fundamental, tofoldal, resonant oscillations of a magnetic field shell. Since the lirse 180 s pulsation started and acopped simultaneously at all three locations and the corresponding eigherite pulsations remained in phase at all three locations, this is interpreted to be a large scale locations. The interpreted to the alarge scale locations. the event was observed at the DE-T sarelitte mear the